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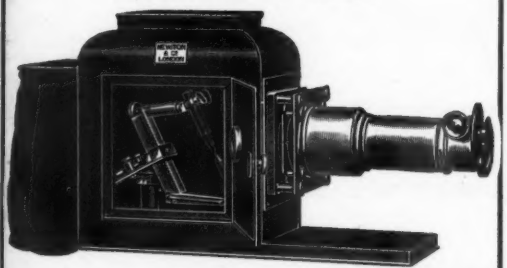

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ANDREW BENNETT, Secretary.

The University,
St. Andrews,
March 8, 1920.

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J. L. HOLLAND,
Secretary for Education.

County Education Offices,
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THURSDAY, MARCH 11, 1920.

The State and the National Museums.

WHILE reconstruction in almost every direction is in the air, there is a very real danger that the needs of our national museums may escape notice. The time is, indeed, more than ripe for the State to consider with all due care whether their value to the community might not be vastly increased were there some system of co-ordination between them, the connecting links being of sufficient flexibility to allow each of them to perform its proper work without the irksome trammels that accompany undue centralisation. In the course of two reports issued by the late Ministry of Reconstruction, certain suggestions are made for achieving this end; to them we shall refer later. The proposal which we put forward is not very different, but we consider it to be a more complete solution. To apprehend more correctly the nature of the problem, it will be necessary first to set out briefly the origin and the present position of the principal national museums.

Perhaps without exception the museums came into being, not as parts of some wide and comprehensive scheme, but casually and at haphazard because some particular contingency arose and had to be met. The oldest and most famous of them—the British Museum—was founded in 1753 for the purpose of housing and conserving the valuable collections which had been bequeathed to the nation by Sir Hans Sloane, a great antiquary and collector in his day. In the following century the growth of the collections was so great, fed as they were by donations, bequests, and parliamentary grants, and, as regards the library, by the operation of the Copyright Act, that it became necessary in the early 'eighties to transfer the natural history collections to the new buildings at South Kensington which had been erected for their reception. But the rate of growth of the collections tended ever to increase, and additional accommodation was soon urgently needed at both branches of the museum. It was only just before the outbreak of war that a new wing was opened at Bloomsbury by the King and Queen, while the plans which had been prepared for relieving the congestion at South Kensington had, owing to the war, necessarily to be held in abeyance, and it is uncertain when it will be possible to proceed with them.

The original Act of Parliament constituting the museum provided for its governance by a body of trustees; this arrangement still remains, and no exception could be taken to it were it not for the fact that election to the standing committee of the British Museum has come to be regarded as a distinction to be awarded on quite irrelevant grounds, and that, owing in the past to the little attention given to science in the public schools, this process has not in general led to the selection of trustees most suitable for the Natural History Museum. Despite the actual physical distance between the two branches of the British Museum, and the great difference in the character of the work carried on at the two institutions, they are still officially regarded as one museum, and the Natural History Museum is subordinated to the parent establishment, the official title of its director being Director of the Natural History Departments. There can, unfortunately, be little question that the development of the Natural History Museum has been grievously hampered by the persistent attempt made to fit it to a system devised for the older building, and especially for the great library, which has, in fact, always tended to overshadow the rest of the museum.

The institution which was at one time known as the South Kensington Museum originated in the collections which were purchased at the Exhibition of 1851 on account of the excellence of their art and workmanship. Half a century later the need for expansion had become acute, and plans for new buildings were put in hand, but in the reorganisation of this museum wiser counsels prevailed, and the Science Museum was created a separate institution, quite independent of the Art Museum, afterwards known as the Victoria and Albert Museum. The title of the former museum cannot be considered altogether happy, since it is concerned, not with science in general, but chiefly with engineering and applied mechanics. Both museums are administered by the Board of Education.

The Museum of Practical Geology was a necessary concomitant of the Geological Survey, which was instituted in 1832. Plans had been prepared for bringing this museum and the offices of the Survey to a new building to be erected near the Natural History Museum at South Kensington, but the war intervened, and many years are likely to elapse before they reach maturity. Up to a few months ago the Survey was attached to the Science Museum under the administration of the Board of Education, but it has now been transferred to the Department of Scientific and Industrial Research, the creation of which is one of the few beneficent results of the war.

The London Museum, now located at Lancaster

House, was instituted for the conservation of the antiquities of London. The Wallace Collection, bequeathed to the nation in 1897, is contained in Hertford House, which was acquired by the Government for the purpose. Both the last-named museums are under independent bodies of trustees. The Imperial Institute contains large collections of the economic products of the Empire, and a scientific and technical staff has been provided for their conservation and study; it is managed by the Secretary of State for the Colonies, assisted by an executive committee. Towards the close of the war the Imperial War Museum was founded for the preservation and custody of objects and records connected with the war. Besides the museums, there are the various picture galleries in London, all under independent bodies of trustees, and outside London there are important national museums at Edinburgh, Cardiff, and Dublin, all under their own authorities.

Owing to the overlapping of the scope of several of these institutions, there often arises duplication of work and competition for the acquisition of specimens. Thus similar ground is covered by certain sections of the British Museum and the Victoria and Albert Museum as regards art; by the Natural History Museum, the Geological Museum, and the Imperial Institute as regards minerals and rocks; by the Natural History Museum and Kew Gardens as regards the systematic study of plants. There is further overlapping in the range covered by the associated libraries—to some extent that is both desirable and inevitable—but at the same time no attempt is made to ensure that a copy of every important book or periodical is accessible in London.

The lack of co-ordination between the various museums was noticed by the Sub-Committee, under the chairmanship of Lord Haldane, which was appointed by the Reconstruction Committee in July, 1917, to investigate the machinery of Government, and confirmed in its appointment when the Ministry of Reconstruction began its brief existence. In its report published in 1918 (Cd. 9230) the following important paragraph occurs:—

"As regards the other national museums [*i.e.* other than the Geological Museum, the suggested transference of which to the Department of Scientific and Industrial Research was approved] . . . , we think that the responsible authorities might consider with advantage the possibility of entering into regular arrangements, by means of a body representative of each of the museums, and established for the purpose, whereby the spheres of the respective museums should be arranged with a view to the avoidance of competition for objects, and to the development of each museum to the full as a centre of education and research. From the latter point of view it would no doubt be desirable to secure that the Board of Education, and the general organisation for research and information, . . . should be associated with any movement in this direction."

In this connection we may refer also to the third interim report by the Adult Education Committee, which was also appointed by the Ministry of Reconstruction, in its report on libraries and museums (Cd. 9237, 1919), in which it is urged that "the powers and duties of the Local Government Board regarding [the local] public libraries and museums should be transferred forthwith to the Board of Education." Those interested in such institutions promptly took steps to register their strong disapproval of the course proposed; with that dissent we are in full accord. It must be remembered that it is the business of the Board of Education to allocate parliamentary grants to schools and other teaching institutions, and to see that the range of the curriculum of the studies at them adheres to the official regulations, and not to take part in the actual practice of education. A department of which the vision is restricted by the blinkers of sub-heads and schedules is not often able to take a broad view on questions of learning and research.

In our opinion the best solution of the difficulty would be to expand the present Department of Scientific and Industrial Research into a Ministry of Learning and Research, and to bring under it the national museums and picture galleries, as well as the national institutions engaged in research. To ensure proper co-ordination and continuity of policy, the administration of the proposed Ministry should be entrusted to a board of trustees, comprising representatives of the standing committees appointed to control each of the constituent establishments.

We recognise the complexity of the question, and our readers must not assume that we consider the solution which we offer to be beyond criticism and discussion. In the House of Lords on March 3 Lord Sudeley suggested that the Government should appoint a committee on museums and galleries "to consider and recommend how these institutions can be further adapted to public needs, and especially be made throughout the country of far greater use for public benefit and instruction." His lordship made it clear, in the course of the speech with which he intro-

duced the motion, that he had in mind the ordinary member of the public, and particularly the child in the elementary school, and appeared to be under the impression that the expert was already sufficiently well cared for. An instructive feature of the debate is the almost entire absence of any reference to science in general, or to the Natural History Museum in particular. Another revealing point is suggested by a passage in Lord Crawford's reply for the Government, in which, in reference to Lord Bryce's proposal that a central scientific department of the Government should be set up, he said: "Among the purposes for which the Scientific and Industrial Research Department was set up . . . is actually that of acting as a central advisory body on any scientific question in relation to any Government Department"; for, apropos of this statement, we must observe that, whereas every administrative Department is represented by at least one assessor to the Advisory Council, that Department appears to be unaware of the existence of the Natural History Museum. Lord Sudeley's motion was eventually by leave withdrawn; nevertheless, we hope that the matter will not be allowed to rest there. We think, indeed, the question of sufficient importance for the consideration of a Royal Commission, the terms of reference of which should include the system of remunerating the specialist, who at present enjoys a much lower scale of salary than the administrator of corresponding standing, and we strongly urge the Government to appoint one with the least possible delay.

Mathematical Cosmogony.

Problems of Cosmogony and Stellar Dynamics. By J. H. Jeans. Being an essay to which the Adams prize of the University of Cambridge for the year 1917 was adjudged. Pp. viii + 293 + v plates. (Cambridge: At the University Press, 1919.) Price 21*s.* net.

IN a well-developed science two branches are broadly to be distinguished. In the one, an existing state of things is investigated. The subject of research is events immediately connected, forms, functions, and the laws which govern them. The other branch generally marks a later stage, and, basing itself on the results of the first, seeks to reconstruct from the present as complete a picture as possible of the past and even of the future. As in the conception which underlies the theory of relativity, the present, which is the limited subject of experience, is merely a section in time from which a higher manifold is to be deduced. When the subject-matter is biological, the outcome is a theory of evolution. When it coincides with the domain of astronomy, the result is more specifically recognised as a scheme of cosmogony.

There are at least three methods by which attempts have been made to formulate such a scheme. The first, and most trivial, is to seize on some remarkable phenomenon, like Saturn's rings or a spiral nebula, and to see in it a clue which can be followed up more or less plausibly with the help of an exuberant and unfettered imagination. Progress on that line is naturally as limited as it is precarious. The second method is illustrated in its highest form by the work of Sir W. Herschel. It is the way of comparison and classification. The Draper classification of stellar spectra by Pickering is an apt modern example. Without preconception, except such as readily vanished in the light of fuller experience, almost all the stars fell into an ordered sequence, which became more complete and continuous as the material accumulated. To connect the ascertained sequence with a time scale was natural. But the problem has not proved quite so simple as at one time it appeared. In general, when the process is exceedingly slow and the section of experience correspondingly thin, the very direction of the scale is ambiguous, and the method requires to be supplemented by some additional principle. A third method remains. This consists in the study of models having a definite specification as nearly as possible in accordance with cosmic examples, but always within the power of analysis to discuss. The behaviour and development of such a model are traced to their logical consequences with full mathematical rigour, and only after this has been done is an attempt made to find their counterparts in the actual universe. This is the profoundly difficult but promising method adopted by Sir George Darwin, by Poincaré, and by Mr. Jeans in the work under notice.

It is curious how great are the difficulties which surround problems capable of the simplest statement. Three balls are thrown in any given way in empty space. All the intractable difficulties of the problem of three bodies are involved in discussing the subsequent motion under their mutual attractions. Or again, to take the fundamental problem of the present subject, a mass of liquid is stirred into rotation and left to find its shape under its own attraction. What figure will it assume when isolated in space? The following quotation from Thomson and Tait may be worth recalling:—

"During the fifteen years which have passed since the publication of our first edition, we have never abandoned the problem of the equilibrium

of a finite mass of rotating incompressible fluid. Year after year, questions of the multiplicity of possible figures of equilibrium have been almost incessantly before us, and yet it is only now, under the compulsion of finishing this second edition of the second part of our first volume, with hope for a second volume abandoned, that we have succeeded in finding anything approaching to full light on the subject."

The full light, it must be admitted, was rather dim, especially as such results as had been obtained were published without proof. But it sufficed to lead Poincaré to write a celebrated memoir on the subject, and this, with the contemporary and independent work of Liapounoff, has been the germ of all subsequent advance.

The first step had been taken by Maclaurin, who showed that the spheroid was a possible figure of equilibrium. The second solution was found by Jacobi in the form of an ellipsoid with three unequal axes. In the cosmical problem the whole mass and the moment of momentum are given constants; the angular velocity increases as the state of contraction advances, but so slowly that the development follows a succession of equilibrium figures. Thus a body traces out the series of Maclaurin to the point where it meets the series of Jacobi, and where secular stability is interchanged between the two series. Proceeding along the second series, it comes to the first point, discovered by Poincaré, where another possible series intersects. Here the Jacobian series becomes unstable, and it was a question whether the stability passed over to the series of deformations, or whether it disappeared completely at this point, in which case the figures of statical equilibrium would come to an abrupt end and be followed by a rapid change under dynamical conditions.

It was not in Poincaré's nature to embark on the complicated arithmetic needed to solve the question; but this part of the work was supplied by Liapounoff and by Darwin, who arrived at opposite conclusions, the latter maintaining that the deformed figure was stable. These three writers all used Lamé's functions in the discussion, and carried the development to the second order. One cannot help feeling that, in spite of his courage, Darwin was in this instance trying to stretch a bow a little beyond his strength. At any rate, the important problem remained undecided for some years. Mr. Jeans began his attack on it by forging a lighter and handier weapon, described in chap. iv. of the present work, on the gravitational potential of a distorted ellipsoid. His next step was to show that no conclusion could legitimately be drawn from a development to the second order; and finally, on proceeding to the third order, he proved definitely that the figure at the point where the series bifurcate is unstable, thus closing a dispute remarkable in the case of a definite issue between authorities so eminently qualified. After this signal achievement as regards the incompressible fluid mass Mr. Jeans extended his researches to rotating masses of compressible and heterogeneous fluid, hitherto an almost untouched field. In following out the development of such bodies as exemplified in different selected models, he has shown always the same originality, resource and power.

In the present essay, which will be warmly welcomed, Mr. Jeans brings together these and other related researches in a connected form, but at the same time he adds so much of the work of his predecessors that his own is seen in its proper setting, and the whole book forms a fairly complete treatise on the subject. The earlier chapters provide that firm mathematical foundation to which the author has contributed so largely, while the later chapters deal in turn with the different classes of celestial objects to which the theory can be applied—rotating nebulæ, star clusters, binary and multiple stars. The origin of the solar system, the very point at which speculations of this order began, remains apparently more elusive than ever. The later part of the book can be read with profit by many to whom the power of appreciating the earlier mathematical chapters has been denied. It will be found exceedingly interesting, and will repay the most careful attention. Here the speculative element necessarily enters, and the permanent value which belongs to the abstract problems definitely solved cannot be assumed. But ingenuity and a wide knowledge are always in evidence, and the essay should have an immediate value equally in limiting the area of profitable speculation and in suggesting lines which can be controlled by observation.

Of the technical excellence of the production, which is always a point of real importance in a mathematical text, it is unnecessary to say more than that it is worthy of the Cambridge University Press. There is an obvious, and therefore harmless, misprint in equation (72) (p. 38), and "Meyers" (p. 248) for "Myers" betrays an unverified quotation. On p. 2, "parallaxes are less" should read "greater." But these are trifling exceptions to the rule of accuracy. Beautiful pictures like the photographs of selected nebulæ included by Mr. Jeans are an unusual feature in a mathematical work. They have been supplied from the Mount Wilson Observatory, and are masterpieces of their kind. H. C. P.

Tropical Medicine.

Fevers in the Tropics. By Sir Leonard Rogers. Third edition. Pp. xii+404+9 plates. (Oxford Medical Publications.) (London: Henry Frowde and Hodder and Stoughton, 1919.) Price 30*s.* net.

THIS, the third edition of Sir Leonard Rogers's well-known work, has, in our opinion, been improved by the pruning process to which it has been subjected, but it may be doubted whether the process has been sufficiently drastic, and personally we should breathe a sigh of relief if the "Burdwan fever" and some other hardy perennials were finally laid to rest. The distinguishing character of the author's method is the great importance which he attaches to the study of temperature charts and to leucocyte counts as means of diagnosis, with the result that, perhaps unwittingly, he scarcely emphasises sufficiently that in diseases of a parasitic nature these can be only of secondary importance. Thus "a great leucopenia" may be "greatly in favour of kala-azar," but a diagnosis can be made with certainty only in one way, viz. by finding the parasites; and as it is not stated whether this has been done in the many examples, accompanied by charts, given of "this disease," we are uncertain whether they really are "this disease," or examples of another disease, possibly the 43 per cent. of "kala-azar" cases in which parasites are *not* found, and which, for all we know to the contrary, may also show "a great leucopenia."

The author's exposition of these indirect methods of diagnosis consumes, we think, too much space, so that pathological histology, which should form our only certain basis for the interpretation of symptoms, receives rather scant attention. Thus nothing is said of the changes in American trypanosomiasis, and those of malaria and blackwater fever, for example, are very incompletely described.

Again, although twenty-one pages are allotted to a discussion of pre-suppurative hepatitis, we ourselves do not know what a liver in this condition would look like, as no post-mortem descriptions are given.

Under blackwater fever it is stated that "the parasite most commonly met with is the malignant tertian, the other forms being rare." If the other forms are rare, as in a malaria district like West Africa, or the Duars in India, this is only what one would expect; consequently, the statement has little significance; but if we are considering a district like the Panama Canal, where the simple tertian parasite forms about 26 per cent. of the malaria cases, then this statement is not true, for we find that about the same percentage—viz. 24 per cent.—of the blackwater cases show simple tertian parasites, and on the Madera River, Brazil, where simple tertian forms about 30 per cent. of the malaria cases, the percentage for the blackwater cases is 42 per cent.

On p. 66 we find a common error repeated—viz. that tsetse-flies in the resting position can be distinguished from all other flies by the wings "closed . . . like the blades of a pair of scissors"; and on p. 86, probably through a lapse of memory, it is said that tartar emetic is specific for American trypanosomiasis; unfortunately, it appears to have no action on it. Misprints are rather numerous: *Crintridia* for *Crithidia*, *Triomata* for *Triatoma*, *lenticularis* for *lectularius*, *sodia* for *sordida*, *tropical* for *tropica*, *galinarum* for *gallinarum*, etc.

Readers who do not already know the work will find something different from the ordinary text-book, but we think they would be glad if the author's well-known clinical enthusiasm could express itself more tersely and—dare we say it?—more critically. J. W. W. S.

Practical Chemistry.

(1) *A Text-book of Quantitative Chemical Analysis.* By Dr. A. C. Cumming and Dr. S. A. Kay. Third edition. Pp. xv+416. (London: Gurney and Jackson; Edinburgh: Oliver and Boyd, 1919.) Price 12*s.* 6*d.* net.

(2) *A Course of Practical Chemistry for Agricultural Students.* Vol. ii. Part i. By H. A. D. Neville and L. F. Newman. Pp. 122. (Cambridge: At the University Press, 1919.) Price 5*s.* net.

(3) *Chemical Calculation Tables: For Laboratory Use.* By Prof. H. L. Wells. Second edition, revised. Pp. v+43. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1919.) Price 6*s.* 6*d.* net.

THERE is always a tendency among students of analytical chemistry to value their work by its quantity and the nearness of their results to what is assumed to be correct, and in this they are often encouraged by those who have the direction of their studies. They do as they are told in their text-book—weigh out so much, dissolve in 200 c.c. of water, add 20 c.c. of a stock reagent, heat to boiling, wash three times by decantation, and so on; and in the end, though they get an excellent result, they have learned not so much chemistry as if they had made an apple dumpling by intelligently following the instructions of a cookery book.

There is only one way to learn practical chemistry, and that is to study the work as well as do it. A student should not pass from an estimation until he knows definitely the reason for every step in the process, how it can be proved to be complete, and why the operation is done in the way it is rather than in an alternative way. He should make a rule of proving that his product is what he means it to be, and that it is pure. In short, he should make a thorough study of every piece of work. He may get fewer results, but he will have learned more chemistry, and he will have gained the only true confidence, namely, that founded on knowledge.

We deprecate, as a rule, general instructions, such as that every precipitate should be ignited two or more times until it ceases to change in weight. Some products need it, some do not. The point for consideration is, What is present that it is desired to get rid of by the ignition, and what conditions are necessary to eliminate it with certainty? Unless the student knows this and concentrates his attention upon it, he is working by mere rule of thumb. As to purity of product, we have known a conscientious and careful worker to get a good result for one of the minor constituents of an ore, but when it was suggested that he should examine the product that he had weighed, he did so, and found that it did not contain even a trace of the compound of which he thought it consisted.

(1) The manual by Drs. Cumming and Kay is an excellent text-book for students. It includes a full course of mineral analysis, finishing with instructions for the analysis of several alloys and ores, gas analysis, water analysis, organic analysis, the determination of molecular weights, and various desirable tables. There are many helpful and practical hints, though we think that some parts might profitably be a little expanded on the lines indicated above. The method of igniting ferric hydrate without separation from the filter paper containing it is, of course, not original with the authors, but we think that it will be found generally to lead to a notably short weight, because the reoxidation of the reduction products is very uncertain.

(2) This "Part" of Messrs. Neville and Newman's course deals only with exercises on "pure organic chemistry." It covers the examination of many classes of organic bodies, finishing with proteins and enzyme action. It is a well-arranged course for students of agriculture. Like so many others who refer to the production of acetaldehyde for detection purposes, the authors describe its odour as characteristically fruity.

(3) The "Chemical Calculation Tables" include a five-figure table of logarithms with a double thumb index that enables the user to turn immediately to any desired page either backwards or forwards. There are extensive tables of factors and weights, giving both the number and the logarithm, and tables referring to gas calculations and molecular weight determinations. It is exactly what one wants to facilitate calculations in the laboratory. C. J.

Botanical Guides.

(1) *Applied Economic Botany: Based upon Actual Agricultural and Gardening Projects.* By Dr. M. T. Cook. (Farm Life Text Series.) Pp. xviii+261. (Philadelphia and London: J. B. Lippincott Co., 1919.) Price 7*s.* 6*d.* net.

(2) *Some Familiar Wild Flowers.* Photographed by A. E. Sulman. Pp. ii+65. (Sydney: Angus and Robertson, Ltd., n.d.) Price 1*s.* net.

(3) *Australian Wild Flowers.* Photographed by A. E. Sulman. Second Series. Pp. ii+61. (Sydney: Angus and Robertson, Ltd., n.d.) Price 1*s.* net.

(4) *A Popular Guide to the Wild Flowers of New South Wales.* By Florence Sulman. Vol. ii. Pp. xxxi+249+71 plates. (Sydney: Angus and Robertson, Ltd., 1914.) Price 6*s.* net.

(1) THE title of Dr. Cook's book is misleading; from the preface we learn that it is intended as a guide to experimental work in the study of plants, such as should be carried on in any high school, and as a preliminary work to the agricultural studies which are now recognised in many high schools. These objects would be served by a good general practical introduction to the study of plant life, and this, we gather, is what Dr. Cook is attempting. Part i., "Plant Life," occupies nearly three-fourths of the volume. Beginning with the seed and seedling, the form of the various plant organs and their uses to the plant are described in successive chapters, and exercises for practical work are suggested at the close of each chapter. A short chapter on the anatomy of the angiospermous plant follows, then a brief description of the chemical composition and a chapter on plant food and growth, and finally very short chapters on the Gymnosperms, ecological relations, forestry, plant-breeding, weeds, Pteridophytes, Bryophytes, Thallophytes, and Bacteria.

The remainder of the book, part ii., entitled "Important Families of Economic Plants," is an account of a number of plants of economic value arranged in their families, with a short and often very inadequate description of the characters of each family. The general effect is scrappy. There

are a large number of figures, many of which are good, but others are poor, as, for instance, some of those in the chapter on flower-types. A photograph of two ripe ears of Indian corn is described as the pistillate flower. The use of the terms "endogenous" and "exogenous" for the stem of the monocotyledon and dicotyledon respectively is not helpful; and to describe the flower as consisting of "leaves which have been greatly modified in shape and colour" may be misleading. Annual rings are invariably referred to as annular rings. The introduction contains excellent advice on methods of studying botany, but the book as a whole is disappointing.

(2) and (3) The two little books by Mrs. Annie Sulman form a series of very fair reproductions of photographs of some of the common Australian wild flowers, and each is very well worth the shilling. There is no letterpress apart from the short preface and index; the botanical and, where such exists, the popular names are given below each plate, and the colour of the flower is indicated. There is little attempt at arrangement; generally the species of the same genus are brought together, but members of the same family appear in different parts of the books. If the author would arrange the plants in some definite sequence and indicate in each case the family to which the plant belongs, she would add to the usefulness of these little volumes.

(4) Miss Sulman's "Popular Guide to the Wild Flowers of New South Wales" is complementary to the volume previously issued. It forms a very handy and well-arranged working flora descriptive of a large number of New South Wales flowering plants, illustrated by clear, well-drawn, and eminently helpful full-page illustrations. The arrangement is that of Bentham's "Flora Australiensis." There are a useful illustrated glossary, a list of books of reference, a key to the families, twenty-nine of which are included, and, at the end of the volume, a colour index, by which a clue may be obtained to the name of a flower. The descriptions of the plants are clearly written, and a great deal of information is given in a small space.

Our Bookshelf.

Agriculture and the Farming Business. By O. H. Benson and G. H. Betts. Pp. xvi+778. (London: Kegan Paul and Co., Ltd., n.d.) Price 10*s.* 6*d.* net.

MESSRS. BENSON AND BETTS have essayed an ambitious task; it is no less than to make their volume a clearing-house for the mass of valuable scientific information about agricultural problems now accumulated at experiment stations and colleges, but not always wanted by practical farmers. Although the book emanates from a London publisher, it is entirely written for the American farmer.

The scope of the book is unusually wide; it deals with office equipment, crops, animals, manures, soil fertility, implements, motor-cars, roads, education, recreation and health, and finally there is a miscellaneous chapter including such diverse subjects as the removal of stains, the quantity of seed to sow per acre, a planting table, etc. Full information about all these things could scarcely be expected, and yet a vast amount of material is collected. Unfortunately, it is of very unequal value; there are few tables of figures and practically no references; the student wishing to check the data cannot do so, and the farmer seeking information is not told where he can obtain it. Thus, under "The Origin of Wheat," the only information given is: "Just where wheat came from none can say. Some think it originated in the Valley of the Nile or the Euphrates, or possibly that it may have come from Sicily. Wherever it originated, it seems to have developed from one of the wild grasses. Certain scientists think it descended from the lily; others tell us that it is probably a descendant of the wild ammer."

This statement is not very satisfying. Like many others in the book, however, it might serve to whet the farmer's curiosity, and some good would then be served by references to trustworthy specialised books or bulletins. If a second edition is called for, the authors might well seriously consider these points.

A Geography of Asia. By Joseph Martin. (Macmillan's Practical Modern Geographies.) Pp. viii+298. (London: Macmillan and Co., Ltd., 1919.) Price 5*s.*

THE tendency of school geography to embrace too much and so to fail in achievement has been avoided in this book, which is well proportioned and thoroughly geographical throughout. Mr. Martin has the courage to omit considerations of geological structure where it has no direct bearing on human activity. Physical explanations of climatic problems are generally omitted. The diagram of the planetary winds is an improvement on that produced in most text-books, but should have the polar high-pressure areas added. Asia is treated under the larger natural regions, but these are not allowed to obscure the political units which are an essential to a full understanding of world geography.

Each chapter is prefaced by some simple statistical matter on which is based a number of exercises designed in the main for oral answers. At the end of each chapter are a number of mapping exercises. The extent to which wide generalisations are admissible in school geography will always be a disputed point, but statements that certain climates are unhealthy to Europeans, if true, require explanation. Even a school geography should emphasise the part played by the mosquito.

More than fifty excellent black-and-white maps, most of which show relief, and as many finely reproduced illustrations add considerably to the value of the book. One or two small points might be corrected in the next edition. The number of emigrants entering Asiatic Russia was scarcely 250,000 a year immediately before the war. The figure given for Siberia on p. 264 is much too high. It would be more correct to say that the Kara Sea is navigable for two months than that it is ice-free for that period. The railways to Kuznetsk and Minusinsk should be noted. The use of a volume like this must result in raising the standard of geographical teaching, and, incidentally, in justifying full attention to the subject in the school curriculum.

Submarine Warfare of To-day. By Lieut. Charles W. Domville-Fife. (Science of To-day Series.) Pp. 304. (London: Seeley, Service, and Co., Ltd., 1920.) Price 7*s.* 6*d.* net.

THE Allied peoples, to whom the defeat of the German submarine campaign has meant so much, cannot fail to be interested in the means by which that defeat was consummated. Hitherto they have had to rely on scraps of information—perhaps true, perhaps not—whispered in the ear or appearing furtively in the Press. An urgent demand undoubtedly exists for a comprehensive statement of the case. Lieut. Domville-Fife has given us that—and more. His book is full of romance as well as of facts. The victory over the submarine was won, not by any sovereign remedy for their depredations, or by a single weapon invincible in attacking them, but by the cumulative effect of a multitude of devices, each itself imperfect, but employed systematically and in spite of numerous failures. To which must be added—and the author gives this its proper proportion by telling actual incidents in a fine literary style—the bravery and pertinacity of the men on the ships.

The only criticism which is permissible is that the book is somewhat lacking in detailed description of the instruments used—the directional hydrophone, for example. Possibly this omission is due to the continued maintenance of official secrecy in such matters. This probably also accounts for the lack of all reference to certain new devices which were used with considerable effect, or to the development of others which will in future render the action of the submarine increasingly difficult.

Hidden Treasure: The Story of a Chore Boy who Made the Old Farm Pay. By J. T. Simpson. Pp. 303. (Philadelphia and London: J. B. Lippincott Co., n.d.) Price 6*s.* net.

MR. SIMPSON has woven many of the features of modern farming into a story of an American college youth who went to a Pennsylvanian farm owned by a very conservative uncle just about to marry and set up housekeeping. The young man's suggestions for improvements are received with the usual incredulity, the uncle even declining to oil the wheels of the grindstone, because he has never done it before. But before the onslaught of the boy's "git up and git," and the insistence of the up-to-date wife, the uncle's prejudices slowly break down, and in one way and another the old run-out farm is gradually improved. New concrete buildings are put in, the tractor is introduced, the dairy herd is improved, and in course of time the farm becomes a completely modern establishment. The young man receives his reward; the local banker becomes interested in him, a desirable farm falls vacant, and in chap. xiii. (ominously enough) an eligible young woman turns up equipped with brown eyes and shy glances, and although the recorded conversations all relate to agricultural improvements, the perspicacious reader will have no difficulty in forecasting the end.

Flora of the Presidency of Madras. By J. S. Gamble. Part iii. *Leguminosae—Caesalpinioideae to Caprifoliaceae.* Pp. 391–577. (London: Adlard and Son, and West Newman, Ltd., 1919.) Price 10*s.* net.

THE third part of Mr. Gamble's handy little flora contains the remainder of the polypetalous dicotyledons. It includes the Cæsalpinia and Mimosa sections of Leguminosæ, containing many forest-trees and shrubs, and, among others, the important families Combretaceæ, Myrtaceæ, Melastomaceæ, and Cucurbitaceæ. As in previous parts, descriptions are given of families and genera, but the determination of the species depends on the keys in which the characters of the principal organs are fully contrasted. No typographic distinction is made between native and introduced genera, such as Parkinsonia (tropical American) and Eucalyptus (Australian); *E. globulus*, the blue gum, is largely grown in forests on the Nilgiris and other hills, and is frequently found self-sown. Another alien genus appears under the name Delonix, an unnecessary revival from Rafinesque; it includes the familiar "flamboyant" generally known as *Poinciana regia*. As with the previous part, the author has been restricted in the preparation of the work to material available in the great herbaria in this country, but for future parts the Indian collections will again be available.

La Théorie Atomique. Par Sir J. J. Thomson. Traduit de l'Anglais par le Prof. M. Charles Moureu. Nouveau tirage. Pp. vi+57. (Paris: Gauthier-Villars et Cie, 1919.) Price 2.40 francs net.

THIS is a translation of the Romanes lecture of 1914, made during the war under the full inspiration of the Anglo-French comradeship in arms. The translator stipulated that the proceeds should go to the British Red Cross; Sir J. J. Thomson insisted that they should go to the French Red Cross; and, as neither would give way, they finally agreed that they should benefit the Belgian wounded. Prof. Moureu has given an excellent translation, which fully preserves the "*intérêt passionnant*" of the original lecture.

Letters to the Editor.

[The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of NATURE. *No notice is taken of anonymous communications.]*

Gravitational Deflection of High-speed Particles.

MR. LEIGH PAGE has given a very simple method of treating the motion of high-speed particles in a gravitational field on Einstein's theory (NATURE, February 26, p. 692). In one respect his results differ from those which have been obtained by more laborious methods, and I think that some error must have crept in, either through a failure of his approximation or from some other cause. He finds that a particle travelling with the velocity of light would be undeflected, whereas a ray of light is deflected. It would be difficult to reconcile this with the principle of equivalence, which seems to require that the trajectory of a material particle should approach that of a light-pulse as the velocity approaches that of light.

The differential equation of the orbit of a material particle moving with any speed is [Report, Physical Society, p. 51, equation (31·2)]

$$d^2u/d\theta^2+u=m/h^2+3mu^2, \qquad (u=1/r),$$

where the constant $h=r^2d\theta/ds$. It is from this exact equation that the motion of perihelion of Mercury is obtained. For motion with the speed of light $ds=0$, so that h is infinite, and the equation becomes

$$d^2u/d\theta^2+u=3mu^2.$$

The solution is

$$u=\frac{\cos\theta}{R}+\frac{m}{R^2}\left(\cos^2\theta+2\sin^2\theta\right),$$

neglecting m^2/R^2.

In Cartesian co-ordinates this becomes

$$x=R-\frac{m}{R}\frac{x^2+2y^2}{\sqrt{(x^2+y^2)}}.$$

The asymptotes are found by taking y very large compared with x, giving

$$x=R\pm\frac{2m}{R}y.$$

Hence the angle between them is $4m/R$, agreeing with the result for the deflection of light rays.

I have verified by the usual methods the other principal result given by Mr. Page, that for radial motion the force (relative to the co-ordinates used) is a repulsion if the speed exceeds $1/\sqrt{3}$ times the velocity of light.

With regard to the question whether the system of an atom on the sun can be identical with that of an atom on the earth, inasmuch as the warping of space-time is different in the two places, it is clear that the identity cannot be *exact*; but this loophole for escape from the predicted shift of the Fraunhofer lines does not seem to be very promising. If the "intervals" of vibration of the two atoms are not the same, the difference must depend on some invariant of space-time which differs at the two places. I do not think that any invariant of order m/r exists. The simplest invariant which does not vanish is

$$g^{\mu\alpha}g^{\nu\beta}g^{\sigma\gamma}g_{\rho\delta}B^{\rho}_{\mu\nu\sigma}B^{\delta}_{\alpha\beta\gamma};$$

it is rather laborious to work out the actual value of this (since it consists of 65,536 terms), but it appears to be of order m^2/r^4. The Fraunhofer displacement depends on terms of the much greater order of magnitude m/r.

A. S. EDDINGTON.

Observatory, Cambridge.

Gravitational Shift of Spectral Lines.

THE assumption that the equations of motion in a gravitational field can be deduced from a condition of the form $\delta\int ds=0$ is in itself little more than a very natural way of expressing the principle of least action. The greatness of Einstein's theory really lies in the suggestion, made apparently on purely *a priori* grounds, that a certain set of six relations between the coefficients in the formula for ds^2, which are true when no heavy body is near, still hold near one. These are found to make the coefficients determinate, whereas previously they were quite arbitrary, and the observed motions of the planets, including the advance of the perihelion of Mercury, are at once deduced.

The displacement of star images during an eclipse is based on the further very plausible assumption that a light-wave moves like a material particle of zero mass starting from an infinite distance with the velocity of light there. Now that this displacement has become a result of observation, the data are just enough to make it possible to reverse the argument and deduce the fundamental assumption of the theory from observation, as I have done in a forthcoming paper in the Monthly Notices of the Royal Astronomical Society. Neither in Einstein's discussion nor in mine is any identification of ds with an invariable line element in four-dimensional space-time relevant to the theory; and as the application of the theory is purely physical, I think it undesirable that any such abstract idea should be made to appear as part of it. Physically, the invariance of ds means simply that the motion of a particle can be described in terms of any set of co-ordinates we like to choose.

In discussing these phenomena all positions and times are referred to an observer at the centre of the sun, and it is not necessary to determine the relations between his measures and ours, for the uncertainty in these would not affect the observed quantities appreciably. The problem of the shift of spectral lines, however, depends essentially on such a comparison. About part of the theory of it there can be no reasonable doubt, namely, the assumption that the vibration on the earth appears to any observer to have the same period as the vibration on the sun that causes it. What is doubtful is whether the atom on the sun vibrates in the same time as a similar atom on the earth. Einstein assumes that it does not, but that the increase in ds in a period is the same for both, and deduces the shift of the spectral lines.

There is nothing very bizarre about this; it only means that when we move about we must refer our observations to time standards in the place where these were originally used, and not expect that they will serve the same functions if we carry them about with us. An analogy from colour will illustrate this. Suppose we have a standard of redness in the form of a particular red body. We judge the redness of other bodies by comparison with this. Now suppose we go to a place where the prevailing illumination is green, but where our standard of redness is still visible through a window. We then say that none of the things in the room look red, but our judgments as to what outside bodies look red are the same as before. Our standard is now brought into the room. Are we going to say that it looks red still? If we do, we shall have to say that the red external bodies that have not been moved have been changed in colour by the motion of our standard, which is at least inconvenient, and which most people would call absurd. Therefore we say that our colour standard has been altered by its displacement, and choose another standard from among the visible external bodies.

Similarly, if an observer on the earth went to the

sun his time standard would not be that determined by bodies he had carried with him, but the standard found by observing from the sun similar bodies on the earth, and he would judge that his time standards were changed by being displaced. Of course, if they were not changed, the spectral shift would be zero. The colour analogy, however, shows that there is no special reason to believe that they are unchanged, and it certainly seems most likely that the invariable quantity in such a displacement is ds, for this is already known to be of fundamental importance in other problems. The shift, therefore, is probable, though if it were absent it would not be very difficult to construct a theory that would fit the fact.

If it were true that dt was the same for atoms on the sun and on the earth, we might expect our standards of length also to be the same; but this leads to a surprising result, for if they were, the measure of the wave-length of the emitted light would be proportional to $(g_{44}/g_{11})^{\frac{1}{2}}$, so that it would not be possible to continue to use the wave-length as a standard of length; thus such a hypothesis would lead, not to a simplification, but to an added complexity. It may also be noted that the spectral shift depends on the part of Einstein's law that agrees with Newton's, so that the two stand or fall together if this phenomenon is crucial.

Einstein's law, however, rests on firmer ground than the theory of the spectral shift. As to whether this shift exists, the available data on an average point to one of nearly the predicted amount, and are certainly much nearer this than zero. They show a great variation in the amount of the shift, which must be explained before the question can be regarded as solved. Many causes are capable of producing this variation, but what seems to me likely to be the chief does not appear to have received much attention. The prediction rests on the assumption that the vibrating atoms are in similar surroundings, which is plainly false. It is, indeed, required by the theory of stellar evolution that the whole constitution of a star must alter owing to successive types of atom becoming unstable and passing over into more stable forms. Instability demands that the slowest free vibration of the atom has its frequency reduced to zero, and in the process the other periods must be affected. The remarkable fact is not that there are shifts, but that the observed spectra are as much like terrestrial ones as they are.

HAROLD JEFFREYS.

Meteorological Office, S.W.7.

The Position of the Meteorological Office.

THAT the study of the atmosphere and the practical applications of meteorology should be supported and encouraged by the Government is a proposition so obvious that it is accepted in every civilised country. It does not, however, follow that the meteorological service of a country should be conducted as a branch of the civil service, still less of the military service, and British meteorologists must be grateful for the emphasis laid in the leader in NATURE of February 26 on the importance of scientific control of official meteorology.

I do not know enough of the present constitution of the Meteorological Office to offer any criticism of the Air Ministry in relation to it, but I am very strongly in agreement with the resolution of the Royal Meteorological Society as to the importance of full inquiry before changing the constitution of the Meteorological Office, which has led to such remarkable advances in meteorological science since 1905. The transfer to the Department of Scientific and Industrial Research, which you state to have been contemplated at one time by a Committee of the Cabinet, would, it seems to me, have been a natural development of the constitution under the Meteorological Committee, and it would have been free from the dangers to scientific progress which are, not unnaturally, feared from a subordinate position in the Air Ministry. Had a full inquiry been held, I doubt whether the claims of the Air Ministry would have been preferred to those of the Board of Agriculture and Fisheries, the Admiralty, the Board of Trade, and, in particular, to those of the Ministry of Health. The union of the British Rainfall Organization with the Meteorological Office has altered its centre of gravity so far as to make its equilibrium less stable in the Air Ministry than it would be in either the Board of Agriculture and Fisheries or the Ministry of Health. As part of the Department of Scientific and Industrial Research the Meteorological Office would be in neutral territory, and could be equally serviceable to all the great Departments, each of which would naturally be represented on the Advisory Committee controlling the organisation. The position would then be analogous to that of the Geological Survey, which, perhaps, is the official scientific body most nearly akin to the Meteorological Office.

For scientific bodies of this kind freedom from all unnecessary trammels of officialdom is necessary in order to permit the expansion and development which are essential to healthy life and practical usefulness; and in a body of such universal usefulness as the Meteorological Office in its present expanded form some representation of the industrial and economic applications of meteorology upon the advisory committee or other controlling board is nearly as important as the representation of independent men of science.

HUGH ROBERT MILL.

Hill Crest, Dorman's Park, Surrey,
March 2.

THE issue of NATURE for February 26 contained an account of the Royal Meteorological Society's resolution in reference to the transfer of the Meteorological Office to the Air Ministry, a leading article dealing with the same subject, and correspondence on the organisation of scientific work, part of which seems directly applicable to the same theme.

If it be true that the Meteorological Committee is no longer to exist, the society's protest appears amply justified. Otherwise the position of the Meteorological Office as a branch of the Air Ministry, with a scientific advisory committee, would appear not very dissimilar to that of the Natural History Museum; or perhaps a better comparison would be with the Royal Observatory, Greenwich, which is under the Admiralty, the Astronomer Royal being supported by a scientific advisory committee in the shape of the Board of Visitors, of whom only one, the Hydrographer, directly represents the Admiralty, the rest being either university professors of astronomy or else expressly nominated by the Royal Society or the Royal Astronomical Society.

The Meteorological Department at Greenwich, though now in its eightieth year, is too recent to expect direct representation on the Board, especially as its activities have not generally run in the direction of research, but the fact remains that the work at Greenwich has points of contact not only with the Admiralty, but also with the Board of Trade, the Post Office, the Meteorological Office, the Colonial Office, and other bodies. It ought not to be impossible to

give due attention from the Meteorological Office to the requirements of the Board of Trade and of the Board of Agriculture and Fisheries, even though for simplicity, and possibly for financial reasons, it is housed in the Air Ministry and its separate expenses included in the account of that Department.

WALTER W. BRYANT,
Hon. Secretary.

Royal Meteorological Society.

Organisation of Scientific Work.

THE fostering and development of the resources of India by means of scientific research is not a mere question of academic interest, but one on which the very economic existence of the country depends. Fortunately the Government of India has realised the danger of the situation, and is anxious to develop the vast potentialities of the country through the application of science, as Japan has already done with her far more limited resources. It is obvious that the success of the proposed scheme will largely depend on the encouragement of investigation among the Indian students and workers, who will necessarily be the principal recruits for the work of the utilisation of indigenous talent in the services of their own country. A quarter of a century ago, when science teaching was in its infancy in India, I ventured to predict that, through an ever-increasing ingenuity of devices necessary for extending the boundaries of knowledge, there would in the near future be seen in India an advance of skill and of invention among our workers, and that, if this skill could be assured, practical applications would not fail to follow in many fields of human activity.

My anticipations have since been fully realised; for example, the extremely delicate instruments which have enabled me to carry out all my investigations have been constructed entirely by Indian mechanicians, and I have been assured that the most skilled American instrument-makers could not have produced apparatus more delicate. As regards scientific advance in its various departments, it is generally recognised that the present period in India may truly be described as a renaissance.

With reference to the practical scheme now under the consideration of the Government of India, the leading article in NATURE of February 19 states very fairly the comparative merits of the two alternatives, namely, that of centralisation under a proposed Imperial Department, and that of decentralisation, under which research workers will be given as free a hand as possible. Under the centralisation scheme the work of an investigator would depend on the previous sanction of the head of the Service, who would probably not be of any scientific eminence, or might even be without scientific qualification; and, most serious of all, he would not be able to publish his results without the consent of the official head of his special department. The possible abuses of such conditions are sufficiently obvious to all.

Every real investigator is making a great adventure into the unknown, and all the initiative and all the risk must therefore be his own. Nothing could be so disastrous for the growth of knowledge as to place competent men under an incompetent machine.

Finally, who should be the judge of the value of the work accomplished? Such judgment should not be departmental or secret; the verdict should come from the open court of the scientific world itself, and this would effectively put an end to official or non-official incompetence.

J. C. BOSE.

33 Bloomsbury Square, London, March 6.

Photographs of Seven Vocal Notes.

DR. A. O. RANKINE, by means of the invention described by him in NATURE of February 5, has placed me under a great obligation in furnishing ocular confirmation, desirable for those whose hearing is undisciplined or poor, of observations made by the unassisted ear on the inherent pitches of vowel sounds. No one who can hear harmonics of a sustained note from the larynx reinforced successively by a continuous change in the pitch of the mouth-cavity acting as a resonator should remain in doubt as to their place in the tablature, for, the pitch of the voice being known, if a harmonic sequence is heard, such as 4 : 5 : 6 : 7, the vibration number of any one of these overtones is the product of a simple multiplication. The well-known spherical resonators, applied in turn to the ear, cannot be changed instantaneously, destroy the all-important contrast, and have failed. The late Lord Rayleigh's compound resonator (*Phil. Mag.*, 1907, p. 321) would do better service, but I do not know that anyone has used it for this purpose. The table in text-books of physics, physiology, etc., shows an extreme error of two octaves. The inherent pitches of the vowels of ordinary speech from *oo* to *ee* range from about f^{ii} to d^{iv}. Taking two octaves as the extreme compass of the mouth shaped for vowels, this supplies such "real characters" for vowel sounds as Bishop Wilkins and his friends looked for in vain, and the use of an alphabet thus rectified will make it unnecessary for English-speaking children to learn to spell, while the re-formed print writing will obviate spelling reform. I have explained this seeming paradox in a book now in the press.

The films were marked before exposure.

(1) "128 not, ?6." This means that a note *c* physical pitch is to be sung in which the singer hears the sixth harmonic intensified in the mouth, the vowel-quality more or less resembling the vowel in *not* prolonged. When the negative was changed back into sound by Dr. Rankine, the harmonic no longer in question (6, g'') was clearly heard by him, and afterwards by myself. The octave comes out in the photograph surprisingly strong. I suspect that it may be largely a self-combination tone. I do not with certainty distinguish the octave in any quality of my voice unless it is strengthened in the mouth, as when the vowel *oo* is sung to a top note of chest register.

Six more films were exposed on February 16. Brief samples of all six are here shown.

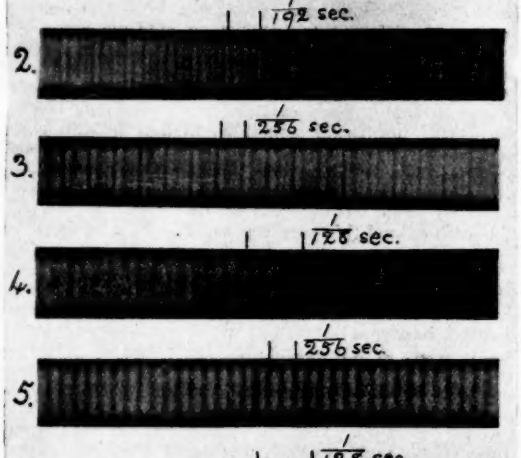
(2) "192 not, ?4." The voice being raised a fifth, to *g*, the mouth-tone g'' is now harmonic 4. The four light bands and four dark lines in each period are evident. The inequality of the spacing reminds us that the thing photographed is not a simple tone with the double octave imposed upon it, but a *voice* in which the fourth harmonic component is made especially prominent.

(3) "256 not, ?3." The voice at middle C, c' physical pitch, the overtone g'' is now harmonic 3.

(4) "128 book, ?5." The pitch of the resonator is lowered to e'' by an unusual protrusion and rounding of the lips. The pitch of the vowel in *book* as spoken in southern England is considerably higher than e''. One vibration in each periodic group is of the frequency 128×5. The rest appear displaced by the octave or the double octave.

(5) "256 book, ? high." The quality of the vowel is not affected, but now the pitch of the resonator is too remote from the nearest of the lower harmonics of c', 2 and 3, c'' and g''; and the only tone audible from the mouth is a very high, thin sound, noted more than once as undoubtedly a sharp F, harmonic

11 of c', $f^{iv}+$. No such frequency is visible on the film, which seems to have recorded only the fundamental and the octave. This vocal note might fairly be called a "dud." Though sustained with greater effort than (3) above, there is no *ring* in it, energy being wasted in the attempt to force a vibration in a mistuned resonator. When a singer happens upon a note of this kind he instinctively alters the oral configuration. Hence the endless complaints that some vocalists, no matter what language they sing, distort the vowels. It is impossible always to combine good resonance with purity of vowel sound, and the higher the voice, the more frequent the occurrence of such an unfavourable conjuncture as here illustrated. It is a matter of arithmetic.



(16) "128 not, ?6." The seventh harmonic was not on the programme. The proposal was to repeat (1) louder. The note began well, but while forcing the voice I became doubtful whether I could hold out until the one second which was to receive duration had come and gone, and listening anxiously for the click of the shutter lost ear-control of the harmonic. In fact, I have to confess to a facial lapse, as sometimes happens when one is having a photograph taken. A slight enlargement of the lip-opening in the direction of the vowel in *far*, a nearer approach to the vowel in *not* as I speak it naturally, introduces harmonic 7 of the fundamental 128. It would be easy to demonstrate this at another sitting. The earlier part of the film is all at sixes and sevens. The strip reproduced with its apparently lop-sided octave proves that the period has been correctly marked in (1).

(7) "128 Somerset R." It was hoped to discover why the Wessex or American *r* should sound harsh to unaccustomed ears. So far, the ear tells me more than the eye.

It would be interesting to try a longer film marked "128 we may, pa, all go too, ?17 to 5."

W. PERRETT.
University College, Gower Street, London, W.C.1, February 27.

Scientific Direction of Industrial Research.

EMBODIED in its rules, the National Union of Scientific Workers states that one of its objects is "to secure in the interests of national efficiency that all scientific and technical departments in the public service, and all posts involving scientific knowledge, shall be under the direct control of persons having adequate scientific attainments." The executive committee of this union realised that it had to overcome much prejudice existing against the application of this rule to the older Departments of State; but from the very circumstances which gave birth to the Department of Scientific and Industrial Research it imagined that the Department would adopt this rule as a cardinal principle, and enforce it in its relations with the many manufacturers' associations the co-operation of which was invited in the formation of research associations for the benefit of British industries.

Until the great war cut off supplies from Germany the British nation as a whole had realised neither its dependence upon that country for dyes, drugs, instruments, and glassware, among other things, nor the fact that great German industries had been founded upon the original work of British men of science. The war brought enlightenment; the nation discovered that its manufacturers, either from apathy or ignorance, had failed to exploit British brains for the benefit of the British communities; and it is safe to assume that the Department of Scientific and Industrial Research came into being to remedy this state of things and to bring the manufacturing interests into touch with the real scientific worker as distinct from the essentially "business" man.

The appointments of Sir Herbert Jackson, Prof. Crossley, and Dr. Slade as directors of research of different industrial research associations were welcomed by this union as an indication of the Department's acceptance of the principle laid down by all men of science, but later appointments have given rise to dismay, particularly that of Mr. R. L. Frink as director of the Glass Research Association, referred to by Dr. Travers in NATURE of February 5. Mr. Frink appears to have been successful as the head of a commercial organisation connected with the window-glass and bottle-glass trade, but careful inquiry has failed to provide evidence that by training or experience he can claim to be a man of science.

My union feels compelled, therefore, to protest with all its power against the appointment. It has sent its protest both to the Glass Research Association, which made the appointment, and to the Department of Scientific and Industrial Research, which approved it. From the former no reply has been received, although a month has elapsed since we made our protest; from the latter the following extracts from the reply are a confession of impotence to deal effectively with the matter:

"It is the intention of the Government that, so far as the conduct of the affairs of research associations is concerned, this shall be in the hands of the associations themselves. . . .

"Accordingly, the responsibility for the selection of a director of research and for the conditions of his

appointment rests in each case with the research association, and not with this Department."

In the case of the Glass Research Association the State contribution to its funds for the next five years is three-quarters of the total. In view of its relatively large contribution, the State should be able to exercise more than a merely nominal control over the appointment of the director; if it cannot do so, it should take immediate steps to remedy its position.

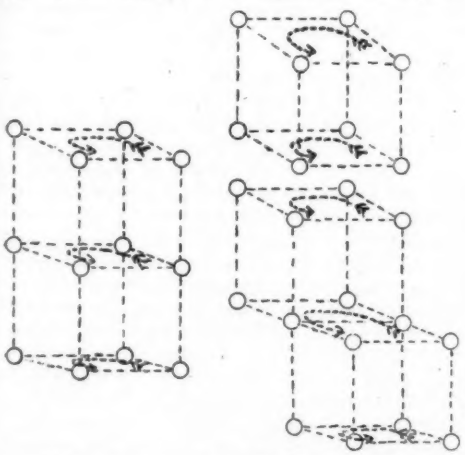
It is the opinion of the National Union of Scientific Workers that it is the subordination of the scientific worker to the "business man" which has been chiefly responsible in the past for the tardy development of scientific industry in this country. It feels that this appointment negatives the aims outlined by the Department, and that the whole industry will suffer from the consequent neglect of the scientific aspects of glass research work and from the unwillingness of scientific workers to submit to such direction.

We firmly believe that the matter is one of the first importance, and that the result of our representation in this matter, not only with a commercial organisation, but also with the Department charged with the care of scientific interests in the country, may determine the relations of science and industry for many years to come. A. G. CHURCH,
Secretary.

19 Tothill Street, Westminster, S.W.1, March 6.

On Langmuir's Theory of Atoms.

THE great objection to Langmuir's theory of atomic structure is the difficulty of accepting his hypothesis of stationary electrons. In view of the extraordinary power of the theory, it is important to inquire if



Langmuir's argument from the fixity of direction of the valency forces necessarily holds. There appear to be various ways in which the rotation can be imagined of the stable groups of electrons formed by the combination of atoms. The figures represent diagrammatically, according to Langmuir's system, rotating groups of electrons in the outer shells of molecules of neon, fluorine, and oxygen. In the case of the fluorine molecule the six electrons, forming two quartets with two electrons in common, may revolve as a whole. The same thing may happen in the oxygen molecule, or the electrons may revolve as three quartets. Revolution of the stable groups of electrons would add to the stability of the molecules formed by their combination and increase the directional steadiness of the valency forces. In this way it may be possible to reconcile Langmuir's theory with that of Bohr. S. C. BRADFORD.

The Science Museum, South Kensington, London, S.W.7, February 16.

Seconding of Officers for Study at Universities.

THE War Office Memorandum recently issued rightly points with satisfaction to the arrangements made to allow Regular officers to take a full course of study at a university (A.O. 323 of 1919). Unfortunately, however, the conditions under which officers may avail themselves of this privilege are such that only the wealthy ones will be able to take advantage of it, for while seconded they will receive no pay or allowance from Army funds; indeed, it has not even been decided whether the whole or any portion of the period spent at a university will count towards pension.

I venture to suggest that pressure should be brought to bear on the War Office to secure that these privileges shall be open to officers of small means by allowing them to retain their pay and allowances during the time they are undergraduates.

J. WERTHEIMER.

Merchant Venturers' Technical College, Bristol, March 8.

Scientific and Technical Books.

ONE part of the Descriptive Catalogue of the British Scientific Products Exhibition organised by the British Science Guild last year was devoted to selected lists of books on science and technology.

The guild has been asked to extend these lists, so as to include not only all branches of science, both biological and physical, but also the chief technical subjects. It has undertaken to do this, and a committee, of which I am chairman, has been appointed to prepare such a catalogue.

The lists will be limited to books of British origin actually in current catalogues of the publishers, so that they can be obtained in the usual way through booksellers. School books and elementary manuals will not be included, and the general standard will be that of college courses in scientific and technical subjects or of works libraries. Each list will be submitted to authorities upon the subject with which it deals, but in order to secure that no important work is omitted the committee invites the assistance of everyone interested in its task. Such aid may be afforded by sending (to the British Science Guild, 6 John Street, Adelphi, London, W.C.2) lists or single titles of British books of standard value or proved worth in any branch of science or industry. I shall much appreciate help of this kind which any readers of NATURE may be able to give. R. A. GREGORY.

Daylight Saving and the Length of the Working Day.

SUMMER time this year is to begin on March 28 and end on September 27 (NATURE, February 26, p. 701). In this connection it may be of interest to point out one effect of the Daylight Saving Act which appears to have escaped notice.

During the six months when the Act is in operation the physiological working day is lengthened by one hour—that is to say, we are all practically compelled to be in active movement (of body or brain) for an hour longer than we normally should be. This lengthened day is accompanied by a curtailment of sleep, particularly in the case of working men who have to rise early, and children. It would be of interest to know the effect of these conditions on the worker's rate of production and the demand for shorter hours.

ANNIE D. BETTS.

Hill House, Camberley.

Rainfall and Land Drainage.[1]

By DR. BRYSSON CUNNINGHAM.

THE problem of the economical disposal of surplus rainfall in cultivated districts is one which naturally engages the attention of the agriculturist and, as a consequence of his needs and interests, of the meteorologist, the engineer, and the lawyer. All three aspects of the matter have been dealt with recently in an article in *Engineering* and in two papers read before the Surveyors' Institution.

The precipitation of atmospheric moisture is counterbalanced in part by the processes of (1) evaporation, (2) transpiration, and (3) percolation, the residue forming the run-off which collects on the surface of the ground and ultimately finds its way to sea by watercourses, either natural or artificial. In cultivated areas it is essential that the soil should be drained promptly and effectively, and left in a "moist," as distinguished from a "wet," or saturated, condition. Ill-drained land is incapable of experiencing the full benefit of those seasonal physical and chemical changes which promote the growth and development of crops.

The article by Lt.-Col. Craster discusses the proportion of run-off to rainfall, and the author finds that it varies in this country, as also in America, roughly between the limits of 33 and 67 per cent. It has been found that 0·065 in. of water is required to wet a crop of rough grass about 5 in. in height, the aftermath in a hayfield, up to the point at which it commences to drip on to the soil. It may therefore be assumed that the amount of water required to wet vegetation and the surface of ploughed land is not less than 0·04 in. or 1 mm. The whole of this amount is lost by direct evaporation after every fall of rain. If the number of days with a rainfall of 0·04 in. or more be 127 (as in the North-East of England in 1918) and the number of days with less rainfall be 67, the direct evaporation for this area will be $0{\cdot}04 \times 127 + 0{\cdot}02 \times 67 = 6{\cdot}42$ in. As regards transpiration (*i.e.* absorption by vegetation), figures from German sources show that a beech wood transpires 14·2 in. of water per year; a crop of oats, 8·98 in.; and a crop of barley, 4·88 in. For an average of 9 in. per year this would be divided as follows: July, 25 per cent.; June, 18; August, 15; May, 12; April and September, 8 each; March and October, 5 each; and the remaining months, 1 per cent. each. Percolation is more difficult to estimate, owing to variable geological conditions, but, as a rough rule, may be taken at not less than 10 per cent. Summarising these figures for the North-East coast of England, there would be a residue, or run-off, of 8·7 in. out of an annual rainfall of 26·8 in., *i.e.* 32·5 per cent., and for Fort William, Inverness, a run-off of 52·67 in. out of an annual rainfall of 78·7 in., *i.e.* 67 per cent.

From a survey of the flood discharges in England and Wales, Mr. Clayton arrives at the conclusion that, while no general rule can be laid down, it is permissible to assume that in average areas the run-off to the sea is from 50 to 60 per cent. of the total rainfall. As the general average rainfall is about 32 in. per annum, this means that, roughly, 1800 tons of water per acre finds its way annually into rills, brooks, streams, and rivers. Taking into consideration the fact that about 60 per cent. of the whole rainfall occurs in the six months October to March, the general proposition is established that 36 per cent. of the total rainfall has to be received by watercourses during a period of 182 days, whence it follows that an average wet period run-off to sea is 0·0633 in. per day. In designing drainage channels and in order to cover reasonable cases of abnormal rainfall, Mr. Clayton advises that this figure should be multiplied by 5, and the result so nearly equals 1 per cent. of the total annual rainfall that he recommends the adoption of this standard.

The calculation is pursued further to the determination of the flow in tidal rivers necessary to discharge this accumulation of land water. Applying the rule to a catchment area of half a million acres, the total volume to be discharged within an ebb-tide period of fourteen hours per day is 576,000,000 cu. ft., or, say, 11,430 cu. ft. per sec., which for a distance to sea of twenty miles would necessitate a channel with a theoretical mean area of 2721 sq. ft.

The maintenance and deepening of these outlet channels are important considerations, but, unfortunately, the jurisdiction and supervision exercised over them are casual and unsystematic in the extreme. Before the railway era, river and canal navigation brought in revenues from tolls which enabled due regard to be paid to the drainage needs of the districts through which they passed, but the decay of inland navigation has resulted in the loss of these financial resources, and drainage conditions have, in many cases, become deplorable. This view is endorsed in Mr. Konstam's paper, which deals with the legal and administrative point of view. The startling assertion is made that it is doubtful whether there is a single river in England which is at present in a satisfactory condition as a means of draining water from agricultural land. Whether strictly or approximately true, the situation calls for earnest attention. Drainage authorities—known as Commissioners of Sewers in many parts of the country—date back to medieval times, and their powers and functions have, in many cases, become ineffective and obsolete. The Land Drainage Act of 1918, however, does something towards alleviating the situation by enabling the Board of Agriculture and the Ministry of Transport to sanction the transfer of a navigation undertaking to drainage functions. No doubt in process of time some degree of co-ordination and system will be established.

[1] "Estimating River Flow from Rainfall Records." By Lt.-Col. J. E. E. Craster. *Engineering*, January 2.
"Land Drainage from the Engineering Point of View." By C. H. J. Clayton.
"Land Drainage from the Administrative Point of View." By E. M Konstam. The last two are papers read before the Surveyors' Institution on January 12.

The Work of the Medical Research Committee.

WHEN a certain small fraction of the National Health Insurance funds was set apart for purposes of research, the experiment was regarded even by many scientific men with suspicion or indifference. It was suggested that the State aid, thus provided for research, would result only in creating a new class of Civil Servants, and might, indeed, lead to the sterilisation of such of the younger men as had earned appointment under the scheme by the excellence of their early researches. It was also objected that any concentration of State aid in a central institute or among a single group of workers would be effected only at the price of starvation of the work already being carried out with insufficient means in the various universities and research institutes of the country. The work of the Medical Research Committee during the first five years of its existence has brilliantly refuted such *à priori* objections, and has, indeed, justified the view that the action taken in 1914 represents the greatest advance in the organisation of scientific effort in the service of medical science that has yet taken place in this country. The Committee seized the opportunity afforded by the war, and initiated and supported numerous investigations urgently required for the effective treatment of our soldiers in the field. So well did it succeed that, by the end of the war, it had secured for practically all the men fitted for original inquiry not only the opportunity, but also adequate payment, either by way of commissions in the Navy, or Army, or Air Force, or by research grants.

As the report points out, the casualties and mortality of peace are not smaller and less painful, but only less conspicuous and more familiar, than those of war. For example, the epidemic of influenza killed during a few months more young people in their prime than fell in battle during the whole war. Fully justified, then, are the efforts made by the Medical Research Committee to create and maintain organised scientific work, which shall repeat and continue for the maladies of peace the same success as was effected for those of war. Taking the difficulties of the situation into account, the report is really a wonderful record of achievement.

The Committee carries out its work in two directions. In the first place, it maintains a small nucleus of workers in whole-time service. Most of these will pursue their researches in the central institute, located in the old Mount Vernon Hospital, which has been adapted for this purpose; though, where the object of the work requires it, these workers may be attached to hospitals or laboratories elsewhere. Thus during the past year both Dr. Lewis and Dr. Elliott were attached as whole-time workers to University College Hospital, and other whole-time workers pursue their researches at Cambridge, Oxford, and St. Bartholomew's Hospital. In the second place, the Committee assists organised research already in progress at different universities and medical schools by means of grants made in payment for part-time work. We are glad to see that the Committee declares its desire to assist in this manner the work of the units which are being formed in London for higher clinical teaching and research.

The record of work for the past year must be regarded as highly creditable and a striking testimony to the value of the aid which the Committee has been able to render. Scarcely any aspect of medical science has been left untouched. Collective investigations have been undertaken on tuberculosis, on dysentery, on typhoid and paratyphoid, on the treatment of wounds, and on cerebro-spinal fever and influenza. Fundamental problems of nutrition have been attacked especially by the Committee on Accessory Food Factors, which has carried out researches not only in this country, but also in Vienna, and thrown much light on the causation of rickets and on the factors concerned in normal growth. The investigation of the disorders of the cardio-vascular system, including the causation of soldier's heart (in which such valuable results were attained during the war), has been continued, and a special department for this purpose has been instituted under the care of Dr. Lewis. The research into trench nephritis is being continued by Dr. MacLean and extended to include all forms of nephritis. The report records also the results of researches on the effects of oxygen lack, on chronic arthritis, on wound shock, on industrial fatigue, and on many other subjects.

The great value of the Committee's work is that in a time of transition, when the community is slowly awakening to the value and necessity of research in medicine, but has not yet provided the necessary organisation and support, it is making it possible for practically all provided with the necessary intellectual endowments to take up scientific work, at any rate for a time. No doubt many of these workers will later pass into practice; but the Committee by its action is creating a reserve of scientific workers, from which the country will be able to draw its teachers and teams of research workers, when once it recognises the need for them and is prepared to provide such salaries that a man can devote himself to the advancement of knowledge without taking vows of celibacy and poverty. There will always be a small handful of men in every country who will devote their lives to this cause. Faradays, however, are few and far between, and the vast majority of men of first-class intelligence are not prepared to make the supreme sacrifice. The country has need of these men to fill its depleted ranks of scientific workers, academic and industrial, but it will not obtain their services until it can provide a career in science equal in status and remuneration to that afforded by other professions.

[1] National Health Insurance. Fifth Annual Report of the Medical Research Committee, 1918-19. Pp. 90. (London: H.M. Stationery Office.)

The Mariner's Compass.

MORE than 300 years ago William Barlow, writing of the compasses of his day, said that, though the compass needle was "the most admirable and useful instrument of the whole world," yet nothing was more "bungerly and absurdly contrived." How little advance was made in the succeeding two centuries can be gathered from Peter Barlow's remark to the Lords of the Admiralty in 1820 that "the compasses in the British Navy were mere lumber, and ought to be destroyed." It was Barlow himself who made the first notable improvements in compasses during the nineteenth century, and his work was the prelude to the important investigations of Airy, Archibald Smith, Kelvin, and others. The practice of "swinging ship"—that is, turning a ship slowly round and noting the deviations of the compass in different positions by taken bearings—was introduced in 1810 by Matthew Flinders, who also invented the use of the "Flinders bar," a rod of soft iron placed near the compass to correct for changes in the magnetism of the ship due to the vertical component of the earth's magnetism.

The gradual increase in the employment of wrought-iron fittings in wooden ships; the use of iron cables instead of hempen; the placing aboard of ponderous iron boilers and engines; and, lastly, the construction of the vessel itself of iron, each in its turn added difficulties to the problems involved. Barlow, in his attempts in 1819 to find a remedy for the large deviation due to the extending use of iron in ships, made the first experimental investigation of the phenomena of induced magnetism. From his inquiry he was able to give a simple means of correcting ships' compasses by fixing soft iron discs in suitable places near the compass, and he afterwards introduced a type of compass having four or five parallel straight strips of magnetised steel fixed under a card, which remained the standard pattern until Kelvin brought out his famous patent in 1876.

The mathematical investigations of Poisson and of Airy about 1838 led to the introduction of methods of correction by the use of permanent magnets, and also of the well-known soft iron spheres. Many of Airy's experiments were made in the iron vessel *Rainbow* off the old Woolwich Dockyard.

The story of Kelvin's share in the improvement of the compass has often been told. Asked in 1871, by his friend Norman Macleod, to write an article for the newly founded magazine, *Good Words*, Kelvin chose as a topic the mariner's compass. The first part of his article appeared in 1874, and the second not until five years later. "When I tried," he said, "to write on the mariner's compass, I found I did not know nearly enough about it. So I had to learn my subject. I *have* been learning it these five years." The Admiralty standard compass, adopted in 1842, and in use when Kelvin took up the matter, had a card 7½ in. in diameter, and under it four needles, each of which was a long, straight bar of flat clock spring placed on edge. The card and the needles weighed about 1600 grains, and had a period of vibration of 19 sec. So considerable was the friction that the binnacle was often kicked by the sailors to make the card move. Kelvin's "gossamer structure" of eight small needles weighed about 170 grains, and had a period of about 40 sec. The cold reception Kelvin received from the then Hydrographer to the Navy, and Airy's remark on the compass, "It won't do," remind one of the reply made to Berthon in 1835: "The screw was a pretty toy which never would and never could propel a ship."

The ultimate adoption of the Kelvin compass was largely due to Lord Fisher, who had one on board the *Inflexible* at the bombardment of Alexandria in 1882. Torpedo craft, however, continued to be supplied with a form of compass in which the whole card floats in liquid, and improvements made in this type led to its being adopted as the standard compass about 1906. Since this has come the invention of, first, the Anschutz, then the Sperry, and, now, the Brown gyro-compasses, the introduction of which has taken place during the last ten years. As remarked by Mr. S. G. Brown in the Royal Institution discourse reproduced below, the gyro-compass is a necessity in a submarine, while in larger vessels it has the great advantages that it can be placed below the water-line more or less immune from gunfire, and lends itself to utilisation with fire-control apparatus and the torpedo director.

All the work on compasses for the Navy is to-day carried out at the new Admiralty compass observatory at Ditton Park, near Slough, where the work of the five departments—the gyro-compass branch, magnetic compass branch, optical branch, experimental branch, and air compass branch—is superintended by the director, Capt. F. O. Creagh-Osborne.

The Gyrostatic Compass.

By S. G. BROWN, F.R.S.[1]

THE subject of this lecture is the gyrostatic compass, often called the gyro-compass. An engineer of my acquaintance was asked if he understood what a gyro-compass was, and he replied, "Of course I do; it is a magnetic compass mounted upon a gyroscope." Now the gyro-compass has nothing to do with magnetism or the magnetic compass. The

[1] Discourse delivered at the Royal Institution on Friday, January 30.

only thing that these two instruments have in common is the property of pointing north and south. I am anxious that this should be clearly understood, because in a recent lecture I gave at Bournemouth on this very subject one of the audience asked me after the lecture how the gyro-compass was shielded from outside magnetic influence. I pointed out, as I had endeavoured to do during the lecture, that the gyro-compass had nothing to do with magnetism, and, therefore, did not require shielding. The magnetic compass and the gyro-compass are, in fact, two absolutely different instruments operated by entirely different laws, although they are for the same purpose.

As many people do not understand why a gyro-compass is needed when the magnetic compass is already available, it is worth while to describe briefly the magnetic or mariner's compass before attempting to explain the gyro-compass. The mariner's compass consists of a magnetic needle, or of several magnetic needles fixed side by side, and balanced upon a sharp point. A card divided into thirty-two (points of the compass) is attached to the needle, and swings round with it, so that the point marked N on the card always points to the north.

The earth, as we know, is a magnet, but not a very powerful one, and it has been calculated that if it were wholly of iron it would have an intensity of magnetism 17,000 times greater than it has. All the same, the magnetism is sufficiently strong to give a good directive action to a pivoted needle. The magnetic poles of the earth are not coincident with the geographical poles, but are situated some distance away. The north magnetic pole was discovered by Sir J. C. Ross to be situated in latitude 70° 5′ N. and longitude 96° 46′ W. in Boothia Felix, just within the Arctic Circle some 1000 miles away from the actual pole.

With this displacement of the magnetic poles we have an irregular distribution of the magnetism over the surface of the earth; and thus the magnetic needle does not point truly north and south at many parts of the earth's surface. In London, for instance, it points at an angle of 16° W. of the true north. This angle is called the deviation or variation of the needle. To enable ships to steer by the compass, magnetic charts have been prepared and the deviation at different places accurately measured. These magnetic charts have to be checked and altered from time to time, as the deviation slowly varies from year to year. Thus in London in 1659 the needle pointed true north, while in 1820 there was an extreme westerly variation of 24½°. Since then it has been slowly coming back to something like 16° at the present time.

On a wooden ship the accuracy of a good modern magnetic compass leaves little to be desired, but on an iron ship the case is quite different. The magnetic field of the earth tends to be weakened in the lengthwise direction of the iron ship, because a portion of the magnetism enters the ship, while across the ship the field is stronger; and as it is essential that the magnetism in which the needle lies should be uniform in strength in whatever direction the ship may happen to point, it is important that this stronger field should be reduced by some method of magnetic shielding. This is accomplished by fixing a pair of iron globes athwart the ship on the two sides of the compass. The effect of the iron of the ship and the corrections that have to be made to the compass is to reduce the directive force of the earth's magnetism, and thus the compass is rendered slow and sluggish in its action. This is particularly the case on board a battleship. In the interior of a submarine the force is still further reduced, so much so as to render the magnetic compass useless for this class of vessel.

It is quite possible on an iron ship to correct the errors of a compass, but as the ship itself may be a magnet, and its strength a variable quantity, it is important that the navigator should test the readings of his compass at every available opportunity, and particularly at the commencement of each voyage. The ship's magnetism may quickly change through the hammering action of the waves, through the heating action of the sun on one side of the vessel, or through an earth on any of the electric wires that may be running near the compass; all these things together add to the anxiety of the captain, as he is never quite certain how far the compass is correct in its readings.

The swings of the modern compass are damped by immersing the needles and card in a liquid such as alcohol, but as this fluid is attached to the ship and turns with it, swinging the ship in any direction carries the liquid round and reacts on the needle and card, so that the compass has a tendency to be carried round with the vessel. This lag in the instrument renders it difficult to hold a ship dead on her course, and the path, as a consequence, is sinuous, and may oscillate, even in a calm sea, as much as 7° each side of the correct heading. As a ship has usually to steam entirely by the readings of the compass, any error is serious. For instance, if there is an error of 1°, and the ship is steaming at sixteen knots, she will move one English mile off her course every hour. It is obvious how necessary it is to have absolutely correct readings.

Lord Kelvin was the first seriously to study the errors of the magnetic compass. He started in 1871, and in 1876 produced his well-known instrument. Although it was a great advance on any compass in the British Navy, he had the greatest difficulty to get it adopted; finally, in 1879 he proposed to place an instrument at the disposal of the Admiralty at his own expense. This offer was accepted. In spite of this, it was only through the acquaintance of influential naval officers, particularly of Capt. (now Lord) Fisher, that the compass was ever adopted. In 1880, eighteen years after the commencement of his experiments, and long after it was in common use in commercial ships, he received official notification that his 10-in. compass was to be adopted in future as the standard of the Navy. It is fortunate that we have an alternative method of securing a north-seeking property in the gyro-compass, an instrument of much greater accuracy than the magnetic and with none of its errors; for if deviations do occur they are known deviations, and can therefore be allowed for.

Evans and Smith, in 1861, were the first to discover how important it was to mount the needles on the card so that the moments of inertia of the moving system should be the same about all directions—that is to say that the system should be in dynamic balance, otherwise the rolling of the ship would cause deviations in the reading. I have lately discovered that another deviation may be brought about, not by an oscillation in one direction, but by the card being set wobbling; the needles and card would then have a force applied trying to carry the moving system round in the direction of the wobble.

I have a magnetic compass here to demonstrate this. It consists of a heavy brass disc mounted on a vertical frictionless spindle. The needles are fixed to the disc, and the whole movable system is carried on a pendulous mounting, as in the gyro-compass. The disc and needles are in correct static and dynamic balance. Swinging the pendulum in any one direction produces no deviation, but by making it swing in a circular conical path, thus giving a wobble to the plate, a serious deviation is caused in the reading of the compass. The error is permanently maintained against the earth's attraction so long as the circular

motion of the pendulum persists. When the compass is carried round in a horizontal circular path without wobble, the plate still goes round, or tries to go round, with a circular movement. This should be of interest to mathematicians.

Before leaving the instrument I will set it spinning so as to demonstrate the frictionlessness of the vertical axis. It is rotating now entirely by means of the energy of the motion of the plate, and I think you will find at the end of the lecture that it is still revolving, but, of course, not so fast as at present.

The magnetic compass is a simple piece of apparatus, but it is complicated in its readings and corrections, and points to the magnetic north. The gyro-compass is a complicated instrument, but simple in its readings, and it points to the true north.

Before proceeding to describe the gyro-compass I wish to direct attention to the equipment here displayed. A gyro-compass is in full operation, and at the present moment is recording its movement upon a travelling strip of paper. About half an hour before the lecture started the compass was deflected from the north position, and it has since been left to itself. The record shows that it is engaged in swinging back

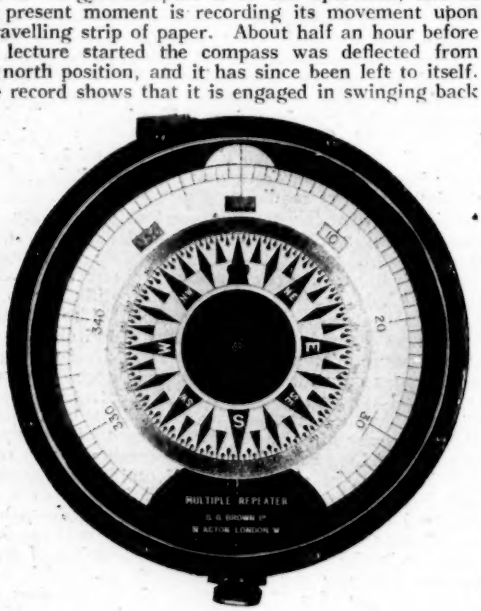


FIG. 1.

again to the north, recording a curve upon the paper strip, and this record can be followed during the whole of the lecture.

The compass is working two repeaters, which truly copy the reading of the master compass. Of course, any number of repeaters could be used on board ship if it were necessary. The steering repeater (Fig. 1) has a card that revolves four times to one of the master, and the divisions are, therefore, very much enlarged. The other is a correction repeater; it moves backwards and forwards very slightly, and this motion we term the "hunt." In the steering repeater the "hunt" has been cut out by providing the mechanism within the case with a requisite amount of slackness.

About sixty-eight years ago Foucault did what was thought a wonderful thing at the time; he gave a lecture-room proof that the earth was rotating on its axis—he looked through a microscope at a gyrostat. He could not get a frictionless, free, vertical axis, so that the experiment could not last for long. I shall be able to show you a piece of apparatus which carries out Foucault's idea in a perfect way, and will be visible to this audience.

A gyrostat consists of an accurately balanced spinning wheel, mounted with as little friction as possible, and in such a way that the axis of the wheel may point in any direction in space. Mere translation in space has no action on the instrument; carrying it about, for instance, does not alter the direction of the axis. On the other hand, the gyrostat is acted upon by any force that tends to tilt the axis or to give the axis a new direction in space.

The wheel (Fig. 2) spins round its axis; call the direction of this *oa*. If we impress a force upon the wheel tending to tilt or rotate it round another axis *ob*, then the rule is that the spinning wheel will "precess" or move in such a direction as to try to make the two axes *oa* and *ob* coincide, and the direction of spin of the wheel to coincide with the new direction of rotation that we are trying to produce by the applied force.

An electric circuit has similar mathematical laws to those of the gyrostat, and may be used as an illustration. The circuit here used (Fig. 3) consists of

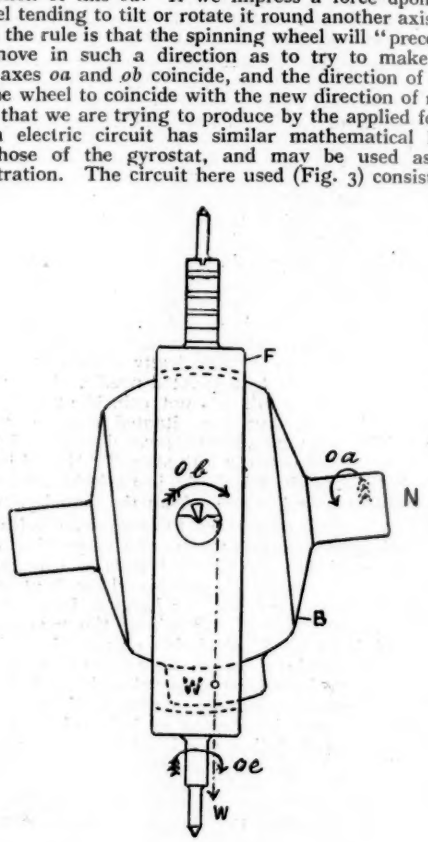


FIG. 2.

an outer fixed coil and a central suspended coil. A strong direct current indicated by *a* is kept flowing in the central coil; this corresponds to the spin of the wheel. If a direct current indicated by *b* is sent round the outer coil, then the central coil will move in such a direction as to make not only the axes of the magnetic fields of the two coils, but also the direction of the two currents, coincide. In fact, the coils will move, or try to move, in such a way as to make the self-induction of the whole circuit a maximum.

This is very much like the gyrostat, or, in fact, any piece of mechanism which under impressed forces tends to move so as to make the whole moment of momentum a maximum. Suppose, therefore, a gyrostat has its axis *oa* fixed parallel to the earth's surface, but free to turn in "azimuth," as it is called, upon a frictionless vertical spindle; the earth will act upon such an instrument, and it would be a gyro-compass.

The earth as it rotates is continually tilting the axis of the wheel in space; the wheel will therefore turn

so as to set its axis of rotation as nearly as possible parallel to the axis of the earth. It is only when the two axes coincide that the wheel is free of any further tilting action—that is, when it is pointing true north; deviate the axis, however slightly, from this position of rest, and the action of the earth comes in again to precess the wheel back again to the north.

Here is a simple form of gyrostat with three degrees of freedom. If I hold it in my hand and revolve on my axis, this does not move the wheel, which still keeps pointing to the same part of the room. On the other hand, if I restrain or clamp one of its degrees of freedom so that I am able to tilt the axis of the wheel during my revolution, the wheel is caused to precess and to set its axis parallel to the axis on which I am revolving. Reversing the rotation, the wheel also reverses.

This is what takes place with the gyrostat on the earth's surface provided it is frictionlessly mounted. Such an instrument is before you, and I will try to demonstrate by its means the rotation of the earth. A wheel is rotating inside this case at 15,000 revolutions per minute. The case is constrained to move

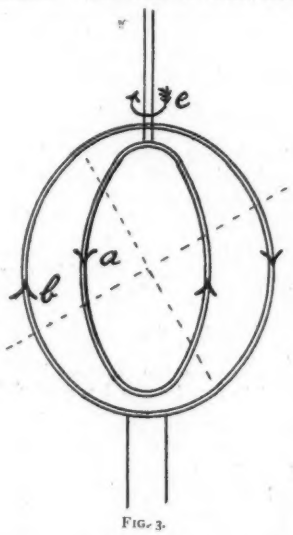


FIG. 3.

about this vertical frictionless axis. Mere motion of translation has no effect in changing the direction of the axis of the wheel, but if this room rotates the axis of the wheel tends to set itself parallel to the axis about which the room is rotating.

We all believe that this room is rotating about the axis of the earth; if so, the axis of the wheel must set itself parallel to the axis of the earth, but it must be kept horizontal, and, therefore, it will point north and south. Here it is pointing in an east-and-west direction; it is held by a string. I will now burn the string, and it will find for us the true north. Observe that it is really the true north direction, whereas that magnet points to the magnetic north. I set it away from the north, but on the other side, and repeat the experiment.

Such a simple form of gyro-compass could not be of any use on a moving ship, because the rolls of the ship would react too violently on the spinning wheel and cause considerable deviations in the readings of the compass. The use of a gyro-compass on land is very limited, and its great value at the present time is on board ship. The spinning wheel is acted upon by forces which tilt the axis. Now, a rolling and pitching ship is about the worst place to put a gyrostat to act as a compass, because the ship's movements all tend to tilt the axis.

The problem, therefore, is to make the compass insensible to the movements of the ship and respond only to the slow angular rotation of the earth. To indicate the severity of the ship's movements, I may recall a recent trip of this gyro-compass on board a fast destroyer. During a severe gale the ship was recorded to roll more than 50° of total angle. Many of the crew were forced to lie on the decks, the lockers emptied their contents, and even some of the oil-lamps suspended from the ceiling were unseated by the pitching of the vessel; yet the gyro-compass maintained its accuracy, and allowed the ship to be steered safely into harbour, to which she had to run for safety. In all this whirlwind of movement the gyro-compass heard, and only responded to, the still, small voice of the earth's rotation.

For use on board ship the compass must be mounted on a pendulum in gymbal rings, and its period of oscillation is lengthened to something like 85', which is usual in practice, so that the rolls, which are of the order of 7 to 15 seconds' period, shall have but small effect on the compass. In this case the rotation of the earth does not act directly upon the gyro-wheel, but by means of the force of gravity through the pendulous weight. Unfortunately, this form of mounting introduces troubles of its own.

Suppose we study our simple gyrostat and see what happens when we attach a weight to the end of the horizontal spindle; this will give us some idea of what occurs when the force of gravity is acting through the pendulum trying to tilt the gyro-wheel.

We know from our law that the wheel will precess under the tilting action, but the new direction of rotation that we are trying to produce by means of the weight, unlike that produced by the earth, which is always in one direction, is in this case continually carried round by the precessing wheel, and the precession is, therefore, permanently maintained. We also find that if we hurry the precession the spindle rises, lifting the weight; while, on the other hand, if we delay the precession, the spindle drops and the weight falls. The rate of precession is proportional to the weight. Halving the weight, for instance, halves the rate at which the wheel rotates round the vertical support.

Coming back again to our pendulous-mounted gyro-compass (Fig. 2); suppose the spindle is pointing west and is horizontal, then the earth as it rotates will leave the wheel pointing in this one direction in space, but the weight will try to follow the earth's rotation, and will start precessing the gyro towards the north. The rate at which the wheel comes to the north depends upon the weight W attached to the casing. All the time the wheel is coming to the north the earth is adding to the rate of the precession, and the spindle is, as a consequence, tilted, and deflecting the weight at the north position. Under these conditions the effect of the weight is to continue the precession, and the gyro-wheel will swing through the north position, and continue to move until the effect of the earth arrests and reverses the motion.

The compass will therefore continue to swing through the north position with constant amplitude backwards and forwards, undamped. To render the compass of use, some method of damping the swing must be introduced so that the compass may finally settle on the north. This damping can be carried out by means of friction, preferably fluid friction, between the vertical spindle and its support; but, although this will damp the swings, it is inadmissible because

the movements of the ship would react through the friction and cause errors in the reading.

Anschutz, in his early form of compass, by use of an air blast, gets rid of this connection with the ship. The air blast was arranged to oppose the movement in azimuth when the wheel tilted, and thus he obtained an effective method of damping. The strength of the air blast, which varies proportionally to the tilt, should be nothing when the compass is at rest on the north—that is, when the tilt is nothing—and this would be true with the compass on the equator.

In other latitudes, however, the compass rests at the north with a tilt still remaining. It does not come back to the horizontal position because the axis of the wheel is trying to set itself parallel to that of the earth. This leaves a residual air blast continuously acting, producing a permanent twist in azimuth and a constant error. It is, therefore, preferable to damp the swings of the compass by acting upon the tilt rather than upon its movement in azimuth, because in this case there will be no latitude error. The tilt is a maximum at the middle of each swing—that is, when it is moving through the north position—and it is the return of the weight to its truly vertical position that is responsible for the continuation of the oscillation; we therefore require some method of neutralising the action of the weight, not before, but after, the compass has reached the north. This I accomplish in the Brown gyro-compass by automatically moving a liquid from one bottle to another, and in such a direction as to counterbalance the weight, precessing the gyro-wheel, and I delay its action by means of a valve or constriction in the tube joining the two bottles.

The force with which the compass seeks the north is proportional to the product of the rotation (one revolution in twenty-four hours) and the spin of the wheel. The faster we can spin the wheel, the more do we obtain directive force. It is for this reason that the wheel is rotated at its maximum speed and strength consistent with the rise of temperature.

Taking the Brown gyro-compass as an example, the wheel, which is 4 in. in diameter and 4¼ lb. in weight, runs at 15,000 revolutions per minute. The maximum directive force of the earth on this wheel—that is, when the spindle is pointing east to west—is only the weight of 30 grains, with a leverage of 1 in. This small force is continually diminishing in value as the axis approaches the north direction, and vanishes absolutely in that position. If the compass was deflected, say, 1° from the north, then the force of restoration is only ½ grain at a leverage of 1 in. It will therefore be seen how important it is to eliminate as completely as possible any friction on the vertical axis that would tend to oppose the directive action of the earth.

There are three forms of gyro-compass now in use: the Anschutz (German), the Sperry (American), and the Brown (British). In the Anschutz the vertical axis is supported by a bath of mercury, and in the Sperry by a suspended wire, the twist, if any, being taken out by a follow-up motor through an electric contact, which switches on the current to the motor; while the Brown is operated by a hydraulic system of support. The lower end of the vertical spindle acts as a ram and stands upon a column of oil. The oil is under great pressure, some 500 lb. per square inch, and is kept pumping up and down, and thus raising and lowering the vertical axis continually some 180 times every minute.

The continual movement of the spindle results in a practically frictionless vertical support, so that the total moving part, some 7½ lb. in weight, can be carried round in azimuth by the smallest force, due to the earth's rotation; in fact, so small is the friction that the compass, if deflected, will always come back again to its true north position, certainly within one-tenth of a degree. I think I am safe in saying that it is the most perfect frictionless support yet given to the vertical spindle of any gyro-compass, or, indeed, of any machine.

In an earlier part of this lecture it was stated that the period of oscillation given to a gyro-compass is of the order of 85′. I will now try to explain why this is so. The earth has no angular movement from south to north, but has one from west to east, due to the daily revolution on its axis. A ship, however, sailing to the north at, say, twenty knots an hour introduces an angular movement in that direction because it is moving over the curved surface of the ocean, and would complete a revolution of the globe in forty-five days.

If there were a gyro-compass on the ship the instrument would be sensible of these angular movements, set itself so as to make a compromise between them, and, as a consequence, point, not to the true north, but one or more degrees west of the actual pole. This division is termed the "north steaming error." Knowing the latitude, the speed of the ship, and its direction towards the north and south, the extent of the error can be accurately calculated, and speed-correction tables have been prepared so that this error can be determined for any latitude, speed, and heading of the ship, and can be allowed for.

Automatic means have also been devised to make these necessary corrections in the reading of the compass. For instance, my special form of repeater has been designed so that the card can be set eccentric, and, when once set, the correction will be automatically applied without any further reference to the tables.

When a ship is in harbour a gyro-compass on board points due north, but when the ship starts steaming to the north the compass begins an oscillation so as to bring the axis of the wheel into the new resting position to include the north steaming error in the reading. Getting up speed will, however, have another effect on the compass. We know that the gyro-wheel is acted upon by a pendulous weight. As the ship changes its speed the acceleration will act upon the pendulous weight and cause an oscillation to be started. This oscillation is termed the "ballistic deflection."

The permanent north steaming error and the transitory error due to the ballistic deflection are in the same direction, and mathematicians have calculated that with an undamped gyro-compass, if the time of its oscillation is set to 85′ in any particular latitude, the ballistic deflection can be made exactly the same as the deflection due to the north steaming error; this being so, the compass should move into its new resting-place without further oscillation. This would be true if, as before indicated, the compass were undamped in its swings, but the mathematicians have overlooked the fact that all gyro-compasses are damped, and the ballistic deflection must, therefore, include a term due to the damping.

This damping term up to the present has been neglected, but in practice it is found that when a ship is steaming and turning to alter its course the compass does not come dead-beat to its new position, but has an oscillation started which is common to all existing gyro-compasses. The extent of this oscillation may be termed the "damping error." On a merchant ship the damping error is of little moment, but on a war vessel which is manœuvring it may be serious, as it may swing the compass off its correct reading by several degrees.

(To be continued.)

Obituary.

PROF. J. EMERSON REYNOLDS, F.R.S.

PROF. JAMES EMERSON REYNOLDS, whose death at seventy-five years of age was announced in NATURE of February 26, was born in 1844 in Booterstown, a suburb of Dublin. His father was a medical practitioner and proprietor of a medical hall, and it was while assisting his father that he first became enamoured of the study of chemistry. Destined to follow in the profession of his father, Reynolds studied medicine, and became a licentiate of the Royal College of Physicians and Surgeons of Edinburgh. Although he practised in Dublin for a short time, his great desire was to devote himself to chemistry, and his chance to discard medicine soon came when, in March, 1867, he was appointed "keeper of minerals" at the National Museum in Dublin, and in the following year analyst to the Royal Dublin Society. It was here that he made his first important contribution to chemistry. In 1869 he discovered thiocarbamide, the sulphur analogue of urea, which he obtained as a result of the isomeric transformation of ammonium thiocyanate. This was a discovery which attracted a good deal of attention at the time, since Liebig and, later, Hofmann had both been unsuccessful in their attempts to isolate the compound—in fact, Hofmann had previously suggested that ammonium thiocyanate was probably thiourea.

Two years later, in a paper communicated to the Royal Society, Reynolds described the preparation of an interesting compound of acetone and mercuric oxide, of the composition $2(CH_3.CO.CH_3),3HgO$, which was the first example of a colloidal mercurial derivative. The conditions under which this body is formed constitute a very delicate reaction for the detection of acetone.

In 1875 Reynolds was appointed to the chair of chemistry in the University of Dublin in succession to the late Dr. Apjohn, having previously been for two years professor of chemistry at the Royal College of Surgeons of Ireland. He quickly established for himself a high reputation as a teacher and lecturer, and for a few years his energies were mainly directed towards the development of the teaching of chemistry on original lines. Shortly after his appointment he commenced the writing of his well-known "Experimental Chemistry for Junior Students," which was ultimately published in four small volumes. The first volume was a distinctly original work. By the aid of a progressive series of simple and well-tested experiments, the junior student was enabled to verify for himself the fundamental laws of chemistry by *quantitative* results. Whilst the quantitative method is now universally adopted in the early training of the student, Reynolds must be given the credit of having been the first to introduce it, now forty years ago. The experimental illustration of his lectures was a matter to which Reynolds gave great attention and a good deal of his time. If, from one cause or another, an experiment failed, which was of rare occurrence, it was always successfully repeated on the following occasion. As a result, his lectures were very attractive, and the discipline which he maintained in his classes was proverbial in the college.

This, it can be understood, was not attained without the display of a certain amount of well-meant severity, and, though Reynolds always refused to nourish popularity at the sacrifice of a surrender of discipline, he was nevertheless held in high esteem by all young men who came under his tuition. Past students have many times spoken to the writer of their great appreciation of Reynolds as a lecturer, teacher, and disciplinarian.

Whilst his professional duties absorbed most of his time, Reynolds continued research, and, from a comparison of the specific heats of silver and beryllium (glucinum), which he had prepared in a nearly pure state, he showed that the atomic weight of the latter must be taken as 9, and that the element was a member of the family of alkaline earths.

In 1885 his researches on organic derivatives of silicon, in which this element was united to nitrogen, were commenced. The results were described in a series of more than a dozen papers published in the Transactions of the Chemical Society up to 1909. Amongst several new substances which were prepared, perhaps the most interesting was the beautifully crystalline silico-tetraphenylamide, $Si(NH.C_6H_5)_4$, the carbon analogue of which has never been obtained, and by the action of heat silico-diphenylimide, $Si(NC_6H_5)_2$, was obtained, the carbon analogue of which is well known. After twenty-eight years' occupation of the chair of chemistry in the University of Dublin, Reynolds retired in 1903, and went to live in London, where he continued work in the Davy-Faraday Laboratory.

Reynolds's last contribution to chemistry, published in the Proceedings of the Royal Society in 1913, was an interesting synthesis of the mineral anorthite, $CaAl_2Si_2O_8$, which he prepared by the combined action of oxygen and water vapour at a high temperature on the synthetic substance $Ca(SiAl)_2$, which he had previously prepared. Reynolds had many honours conferred upon him during his career. He was elected a fellow of the Royal Society in 1880, and vice-president in 1901, president of the Chemical Society 1901–3, president of the Society of Chemical Industry 1891–92, and president of the chemical section of the British Association in 1893. Reynolds died suddenly on Tuesday, February 17, at his residence in London. He was an honorary M.D. and Sc.D. of the University of Dublin. He married, in 1875, a daughter of Canon Finlayson, of Dublin. He leaves two children, a son and a daughter.

E. A. W.

WE much regret to see the announcement of the death on March 9 of M. Lucien Poincaré, Vice-Rector of the University of Paris, at fifty-eight years of age.

DR. SAMUEL HATCH WEST, who died on March 2 at the age of seventy-one, was well known in London as a consulting physician. He was trained at Oxford under Rolleston and Acland, and as Radcliffe travelling fellow he studied in Vienna and Berlin. He was physician to the Royal Free Hospital and to the City of London Hospital for Diseases of the Chest, but his life's work was carried out at St. Bartholomew's Hospital, where he received his medical education, and held successive medical appointments until he became full physician. Dr. West was a successful clinical teacher, and many generations of students will be grateful to him for the thorough manner in which he taught them to examine a patient, system by system, so that no important organ could be overlooked. Dr. West deserved his high reputation as a careful clinical observer. Diseases of the lungs were his particular study, and on this subject he produced a monograph in two volumes which is a monument of industry and a veritable mine of information. He delivered the Lettsomian lectures at the Medical Society of London in 1900, taking as his subject "Granular Kidney," but it is by his teaching and his work on diseases of the lungs that he will best be remembered.

A CORRESPONDENT, "G. P. B.," writes:—"All zoologists who have ever worked at the 'Stazione Zoologica' of Naples will be grieved to read of the death of Prof. Eisig, whose obituary notice by Prof. R. Dohrn appears in the Zürich *Zeitung* of February 19. Hugo Eisig was born in Baden in 1847. When Anton Dohrn, aged thirty-one, decided to sink his whole fortune in the building of the Naples station, knowing that it would suffice to rear up only the ground story, his friend Kleinenberg went with him; Eisig, seven years their junior, offered himself also, and was accepted. Many years of great difficulty followed, and then many years of very great success. Through all Eisig continued the career which he had chosen as part and parcel of the Stazione Zoologica. His contribution to zoology is not to be measured by his published work, even though it includes his great 'Monograph of the Capitellidæ.' To all of us who worked at Naples he was a friend, loyal, sympathetic, unselfish, and gentle. In 1907 Eisig retired on a pension from his administrative post in the Zoological Station, but continued his own zoological work. Two years later Anton Dohrn died, and was succeeded by his able son, but in 1915 Prof. Reinhard Dohrn, with Eisig and others of the staff, had to leave Naples for the hospitality of the Zürich Zoological Museum and Swiss territory. There Eisig died on February 10 last from the after-effects of an operation which appeared to have been successful. He died in exile from his home of forty-four years, but in the warm memory of many friends all over the world."

Notes.

A MEETING convened by the Chancellor of the University of Cambridge and the president of the Royal Society was held on Thursday, March 4, at the rooms of the Royal Society, to consider the question of a memorial to the memory of Lord Rayleigh. After a preliminary statement by the president of the Royal Society announcing the purpose of the meeting, speeches in favour of the proposal to erect a memorial were made by Mr. A. J. Balfour, Sir Charles Parsons, Dr. P. Giles (Vice-Chancellor of the University of Cambridge), Sir Arthur Schuster, Sir Richard Glazebrook, and Sir Joseph Larmor. It was agreed that a fund should be raised for the purpose of placing a memorial, preferably a window, in Westminster Abbey. A general committee was appointed, as well as an executive committee, to consider details, and also the further question of raising a fund in memory of Lord Rayleigh, to be used for the promotion of research in some branch of science in which Lord Rayleigh was specially interested.

A PUBLIC meeting was held in the University Museum, Oxford, on March 6, to initiate a memorial to the late Sir William Osler, Bart., Regius professor of medicine in the University for the past fifteen years. The Vice-Chancellor presided. Sir Clifford Allbutt, who introduced the proposal, paid a feeling and eloquent tribute to the memory of Sir William Osler, to the wide range of his intellect, and to the singular charm of his character. He referred to his international reputation and to the binding influence he had on the medical profession in many lands, to his love of peace and goodwill, and to the extraordinary power he exerted in diffusing without diluting friendship. The president of Magdalen, Sir Herbert Warren, mentioned the many-sidedness of Osler's interests and activities, the breadth and accuracy of his scholarship, and the clear and steady optimism with which he regarded life and its progress in all ages. Sir William Church, who introduced the specific proposal that the memorial should take the form of an Osler Institute of General Pathology and Preventive Medicine, stated that such a memorial as that suggested would be a singularly appropriate tribute to the outlook and ideals that Osler had kept before him in his life-work. Prof. Thomson emphasised the need of new laboratory accommodation in Oxford for teaching and research. The Dean of Christ Church and Sir Archibald Garrod also spoke. It was announced that the hon. secretary, Prof. Gunn, had received expressions of sympathy with the proposed memorial from a large number of people representing many interests, and that a collateral committee had been formed in America to aid in raising the memorial.

A MOVEMENT has been started to commemorate the life and work of the late Sir James Mackenzie Davidson by an appropriate memorial. The proposal is that steps should be taken to found a Mackenzie Davidson chair of radiology at some university, but, whereas nothing could be more fitting as a memorial to the work of one who devoted a large part of his

life to the development of the subject of radiology, it is urged by the thirty signatories of the appeal that, if the wider claims of the subject are to be met, there should be an X-ray institute. The applications of X-rays in medicine have vastly extended both in diagnosis and in treatment during the last ten years, but the new knowledge as to the properties of X-rays revealed by crystal analysis has opened out many new fields both of investigation and of application. If the subject is widening in these respects, there are signs no less clear of a growing need for improved teaching in the many fields of X-ray activity. The institution of a diploma in radiology by the University of Cambridge is but one indication of the demand that exists at the present day for instruction in the subject of X-rays. A well-equipped and well-organised institute seems the most likely way in which the multifarious interests of X-rays can best be welded into an efficient working whole, and it is hoped that the response to the appeal will ensure that the brilliant X-ray work done in this country may be augmented.

THE first post-war meeting of the International Council for the Exploration of the Sea was held in London last week, March 2–6. The countries represented were Belgium, Britain, Denmark, Finland, France, Holland, Norway, and Sweden. France sent a delegate for the first time, and the United States of America was informally represented. The British Government entertained the delegates and others at a dinner at Lancaster House, the Royal Society held a reception at Burlington House, and the Trustees of the British Museum and the Royal Geographical Society also received the delegates. The meeting resolved itself into a number of sections for the consideration of particular questions; these were the formulation of a scheme of research to enable the various Governments to make a convention for the better regulation of the North Sea fishing-grounds; the future conduct of the hydrographic and plankton researches; biological, statistical, and historical investigations with respect to the herring; the European eel fisheries; the fisheries of the seas to the south-west of the British Isles; a limnological survey; international fishery statistics; and certain basal physical and biochemical matters. Much interest was exhibited with regard to the "plaice problem," and the section concerned held several meetings. The hydrographic sectional meetings were very interesting, but it was clear that no immediate results were to be expected. The *personnel* of the Council had not undergone much change. In the death of Sir John Murray the organisation has suffered a great loss, but the genial and forceful personality of Dr. Johan Hjort is still an asset of much value. Prof. Otto Pettersson vacated the chair to Mr. H. G. Maurice, of the English Ministry of Agriculture and Fisheries, to whom the continued existence of the international investigations throughout the period of war is largely due.

ACCORDING to the *British Medical Journal*, Sir Frederick Banbury's Bill to Prohibit the Vivisection of Dogs is down for second reading on March 19. It will be remembered that when the same Bill was introduced last year a Government amendment allowing experiments to be made on dogs under special certificates was carried. The title was also changed. Sir Frederick Banbury himself moved the third reading with these amendments. The Bill was, however, rejected. It is now brought forward again in the form in which it existed before the Government amendments—that is, prohibiting all experiments on dogs. Although there seems some hope that the prospects of its progress in Parliament are not very favourable, its unexpected temporary success last year must not be forgotten, and careful watch is imperatively necessary. It is inconceivable that the Government can allow a Bill of this kind to pass, nullifying, as it does, the activities of so many of their Departments. Sir Frederick Banbury admitted that he had "failed to mention" the safeguards against possible cruelty already existing in the Statute Book. The opinion of the medical profession is sufficiently shown by the unanimous vote of the clinical and scientific meeting of the British Medical Association in London last April. It was agreed that such prohibition of experiments on dogs would have a deplorable effect in hampering the progress of physiological and pathological investigation, since many important fields of research are only available when dogs can be used. They are the only large animals that can be kept in health and comfort under laboratory conditions.

THE admission of qualified medical women to the fellowship of the Royal College of Surgeons of Edinburgh reminds us of the fight waged in the late sixties and early seventies of last century for the admission of women to the classes and examinations of the faculty of medicine of the University of Edinburgh. The fight was lost by the gallant band of women—*septem contra Edinem*. It has been fought and won in the fifty intervening years, and this resolution of the Royal College marks the fall of the last barrier to equality of the sexes in medical education in this ancient seat of learning. Women medical students have recently been admitted to the complete courses in the faculty of medicine, and the extra-mural Edinburgh School of Medicine for Women has been merged into the University. It remains to be seen whether the new *régime* will justify those who have borne much anxiety and labour to promote it. We believe it will. The Scottish women proved their quality in the hospitals they equipped and staffed in the various seats of war. They have started a small hospital in Edinburgh staffed by women only. There is an increasing body of medical women and women students attached to the University, and among them will be found doubtless the same capacity for work and leadership which was so nobly exemplified by the late Dr. Elsie Inglis. With all the examinations open to women which lead to hospital staff appointments, it is hoped that an increasing number of highly qualified women will present themselves as candidates when vacancies occur, and that appointments will be open to merit irrespective of sex. Much of the work to be done in the future in the State-aided hospital is obviously of a character to

demand the services and judgment of qualified medical women.

THE twenty-sixth James Forrest lecture will be delivered at the Institution of Civil Engineers on Tuesday, April 20, at 5.30 p.m., by Sir Dugald Clerk, K.B.E., F.R.S., upon the subject of "Fuel Conservation in the United Kingdom."

PROF. A. FOWLER, professor of astrophysics, Imperial College of Science and Technology, South Kensington, and president of the Royal Astronomical Society, has been elected a corresponding member of the Paris Academy of Sciences, in the section of astronomy, in succession to the late Prof. E. Weiss, of Vienna.

PROF. J. STANLEY GARDINER has, at the request of the Deputy-Minister of Fisheries, undertaken temporarily the direction of the scientific work of the Fisheries Department of the Ministry of Agriculture and Fisheries. Prof. Gardiner's particular duty will be to restart fishery investigations, which have necessarily been in abeyance during the war.

THE Faraday Society has arranged a general discussion on "Basic Slags: Their Production and Utilisation in Agricultural and other Industries," to be held on Tuesday, March 23, from 7.30 to 10.30, in the rooms of the Chemical Society, Burlington House, London, W.1. Prof. F. G. Donnan, vice-president, will preside over the discussion, and there will be papers by Dr. E. J. Russell, Prof. C. H. Desch, Sir T. H. Middleton, Sir Daniel Hall, Prof. D. A. Gilchrist, and others.

THE U.S. National Research Council has received a gift from the Southern Pine Association of 10,000 dollars to meet the incidental expenses of a co-ordinated scientific study by a number of investigators of the regrowth of trees on cut-over forest-lands, with the view of determining the best forestry methods for obtaining the highest productivity. The investigation will be conducted under the advice of the Research Council's special committee on forestry, and will not duplicate any present Government or other undertakings along similar lines.

IT was announced at the ordinary scientific meeting of the Chemical Society on March 4 that the following had been proposed for election as honorary and foreign members, and that a ballot for their election would be held on March 18: W. D. Bancroft, V. Grignard, H. Kamerlingh Onnes, E. Paterno, P. Sabatier, J. B. Senderens, S. P. L. Sörensen, and G. Urbain. The annual general meeting of the society will be held at Burlington House on Thursday, March 25, at 5 p.m., to receive the address of the president, Sir James J. Dobbie, and to elect the officers and council for the ensuing year.

THE following officers and council of the Geological Society have been elected for the ensuing year:—*President:* R. D. Oldham. *Vice-Presidents:* Prof. E. J. Garwood, G. W. Lamplugh, Col. H. G. Lyons, and Prof. J. E. Marr. *Secretaries:* Dr. H. H. Thomas and Dr. H. Lapworth. *Foreign Secretary:* Sir Archibald Geikie. *Treasurer:* Dr. J. V. Elsden. *Other Members of Council:* Dr. F. A. Bather, Prof. W. S. Boulton, R. G. Carruthers, Dr. A. M. Davies, J. F. N. Green, R. S. Herries, J. Allen Howe, Prof. O. T. Jones, Prof. P. F. Kendall, W. B. R. King, Dr. G. T. Prior, W. C. Smith, Prof. H. H. Swinnerton, and Prof. W. W. Watts.

THE first of the Chadwick public lectures on military hygiene was delivered by Gen. Sir John Goodwin, Director, Army Medical Service, on March 8 at the Royal Society of Arts, the subject being "Army Hygiene Prior to the Recent War." The lecturer dealt with the history of hygiene from the earliest times up to the period immediately preceding the war. The ravages wrought by disease during the various campaigns of the eighteenth and nineteenth centuries and their effects upon the armies in the field were detailed, and emphasis was laid on the lessons gained during the South African War in the prevention of disease. The various measures that have been elaborated to improve the health of the Army were outlined, and stress was laid on the good results accruing from education in hygiene of the Army as a whole. In India, during the years 1878–82, the number constantly sick among the European troops was 68·1 per 1000, with a mortality of 20·5; in 1912 the corresponding figures were 28·8 and 4·6 respectively. Immediately preceding the lecture Chadwick gold medals and prizes were presented to Surg.-Comdr. Edward L. Atkinson, R.N., and Brig.-Gen. W. W. O. Beveridge, A.M.S., for services in promoting the health of the men of the Navy and Army.

WE are authorised to announce that H.R.H. the Prince of Wales has been graciously pleased to become the patron of the new British School of Archæology in Jerusalem, referred to in NATURE of December 18 last (p. 398). The school has been formed for the study of the wide and important field of archæological research which has now been opened up in Palestine and the surrounding districts. The director, Prof. J. Garstang, of the University of Liverpool, is shortly proceeding to Palestine to complete the organisation of the school. As soon as the political destiny of Palestine has been fixed and a mandate formally assigned, it is hoped that a department of antiquities will be formed, under which the school looks forward to collaborating with the Palestine Exploration Fund in the excavation of an important site which has already been provisionally selected. Anyone who is interested in the school is invited to communicate with the secretary at 2 Hinde Street, Manchester Square, W.1.

THE Natural History Museum Staff Association opened its series of scientific reunions for the current year by holding a double reunion on March 2 and 3. At the first most of the members of the International Council for the Exploration of the Sea were present, and the exhibits arranged in the board-room included many specimens—some being classical type-specimens—collected during the voyage of the *Challenger*. At the second reunion other exhibits were added, so that the whole series was of wide interest, and there was an attendance of nearly fifty visitors, amongst whom may

be mentioned Lord Rothschild, Sir Ronald Ross, Prof. E. B. Poulton, Lt.-Col. Winn Sampson, Mr. F. E. Beddard, Prof. J. Stephenson, Dr. H. O. Forbes, Mr. R. F. Scharff, Prof. J. P. Hill, Dr. S. Kemp, Dr. B. Daydon Jackson, Prof. J. Graham Kerr, Mr. S. Monckton Copeman, Mr. G. T. Bethune Baker, Dr. E. J. Allen, Dr. H. H. Thomas, Dr. C. Christy, and Prof. J. E. Duerden.

THE half-yearly council meeting of the National Union of Scientific Workers, presided over by Mr. G. S. Baker, of the National Physical Laboratory, was held at University College on March 6. The rapid growth of the union has necessitated the appointment of a full-time secretary, and Major A. G. Church has been appointed to fill that office. The research committee in its report outlined the function of this body and that of the research council, which it is hoped will shortly be constituted. It will consider how best industry and public administration should be kept in close touch with the development of scientific knowledge, and ensure that the views and conditions of employment of scientific workers shall receive consideration from all bodies bringing forward schemes for research in science or for the administration of research. It was felt that the State should not subsidise industrial research associations unless such bodies display an anxiety to ensure that the direction of research shall be in the hands of those who have shown capacity for leadership in scientific work. A report on patent rights presented by Mr. A. A. Griffith emphasised the opinion "that the only satisfactory way of remunerating salaried inventors is to pay them adequate salaries; a salaried inventor receiving an adequate salary should have no claim whatever to any extra payment because his work proves unexpectedly remunerative." On the motion of Miss A. B. Dale, the council unanimously agreed to "protest strongly against the differential treatment of men and women as regards the method of recruitment to the Civil Service and the salary scales offered therein as recommended by the Reorganisation Sub-Committee of the Civil Service National Whitley Council."

FEBRUARY was unusually warm over the southern portion of the British Isles, and at Greenwich Observatory the mean temperature for the month was 43·9°, which is 4° above the normal; the mean, however, was higher in 1914, when it was 44·9°, and the means of both maxima and minima readings were also higher. There were four days with a shade temperature of 60° or above, whilst there is no previous February at Greenwich with more than two such warm days since 1841, and in all only seven days as warm during a period of seventy-nine years. Frost in the shade only occurred on four nights during the month, and the lowest temperature was 27°. The duration of bright sunshine was eighty-seven hours, which is thirty hours more than the normal, and there were three days at Greenwich with eight hours and more of sunshine. Rainfall was much below the normal, and in London there was no day during the month with a fall of 0·1 in.; the total measurement was 0·39 in., which is the driest February since 1895 and 1896. Rain was measured only on eight days. The whole winter, December, January, and February, has been unusually mild over England, and at Greenwich the mean temperature for the three months was 42·8°, which is 3·5° warmer than the average for sixty years. The winter of 1915–16 was slightly warmer, and the winter of 1898–99 was warmer by about 1°. The warmest winter during the last eighty years, 1868–69, was warmer than the winter just ended by nearly 2°.

IN view of the prevalence of disease amongst honey-bees during recent years, it has become a matter of practical importance to be able to distinguish with certainty between individuals which have died from disease and those the death of which is merely the result of old age or exhaustion. Mrs. Pixell-Goodrich contributes an interesting paper on this subject to the *Quarterly Journal of Microscopical Science* (vol. lxiv., part 2). It appears that during the summer, when actively engaged in collecting honey and pollen, the worker-bees very soon wear themselves out and die a natural death at the age of about six weeks. Senescence—or perhaps one should rather say exhaustion from over-exertion—is accompanied by well-marked and easily recognisable changes in the nerve-cells of the "brain." The cytoplasm of these cells undergoes gradual reduction in quantity, until only a vestige remains around the nucleus. The examination of the nerve-cells appears to be the most trustworthy method yet proposed for determining the age of bees, but, unfortunately, it involves a considerable amount of labour in the case of each individual examined.

THE Bulletin of the Bureau of Standards for July 12, 1919, contains the results of the measurements of the index of refraction of air for wave-lengths 2000 to 10,000 tenth metres at different temperatures and pressures made by Messrs. W. F. Meggers and C. G. Peters to meet the demands of modern accurate spectroscopy. The Fabry and Perot interferometer was used in the measurements, the plates being of glass or quartz 4·2 cm. in diameter and 0·6 to 0·8 cm. thick. They were rendered partially reflecting by films spluttered from a metallic cathode *in vacuo*. Iron or copper arcs and neon or argon tubes served as sources of light. The interference rings were photographed and the diameters of the first three measured. Between the limits of pressure used—73 to 76 cm.—the refractive index was found proportional to the pressure. The variation of the index with temperature between 0° C. and 30° C. is not sufficiently well represented by the usual $\mu-1$ proportional to density law. The index of refraction at normal temperature and pressure is given by the equation $\mu^2-1=\frac{0{\cdot}0005738\lambda^2}{\lambda^2-595200}$, which shows no sign of an appreciable absorption band in the infra-red part of the spectrum.

THE annual report of the Institution of Mechanical Engineers gives particulars of the various researches which are being carried on under the direction of the institution. The following grants were made by

the council for the year:—Alloys, 220*l.*; steam-nozzles, 150*l.*; hardness tests, 150*l.*; and cutting tools, 100*l.* The alloys research has been carried on at the National Physical Laboratory, and the eleventh report will be presented at an early date. The construction of the experimental apparatus for the steam-nozzles research has been further delay for lack of funds, but help has been promised by a grant of 500*l.* from the Turbine Blade Research Committee of the British Electrical and Allied Manufacturers' Association. It is intended to erect the apparatus at the Dickinson Street Power Station, Manchester, and the experiments will be conducted under the supervision of Prof. G. Gerald Stoney and Mr. S. L. Pearce. Hardness tests have been carried out at the National Physical Laboratory by Dr. T. E. Stanton, and it is hoped that reports will be presented this year. A bibliography on cutting tools is being prepared by Mr. G. W. Burley, and it is proposed to collect information from makers and users of cutting tools. The work of the wire-ropes research committee has been considerably delayed owing to the war; arrangements have now been made for experimental work to be carried out at Woolwich Polytechnic by Dr. W. A. Scoble. The work of the refrigeration research committee has been suspended since 1914; it is hoped that investigations may be made shortly into the physical properties of the substances used in refrigeration.

A CATALOGUE (No. 357) of rare books and manuscripts has just been issued by *Messrs. Bernard Quaritch, Ltd.*, 11 Grafton Street, W.1, and is worthy of perusal. It is of a fairly general character as to the subjects, but two sections will appeal especially to readers of NATURE, viz. those dealing with natural and physical sciences (21 pp.) and with periodicals (13 pp.). Many scarce volumes and long runs are to be found in these. The price of the catalogue is 1*s.* We notice that Messrs. Quaritch are about to begin the publication of the *Journal of Pomology*. It will appear at quarterly intervals under the editorship of Mr. E. A. Bunyard, who has secured the promise of assistance from many experts.

AN illustrated book on "Weeds of Farm Land," the work of Dr. Winifred E. Brenchley, of the Rothamsted Experimental Station, is to be published by *Messrs. Longmans and Co.* It will deal with various aspects of the weed problem, but especially with the relations existing between weeds and the soils and crops with which they are chiefly associated. A survey will be given in the volume of the present position with regard to the questions of prevention, eradication, and uses of weeds, also of their habits and method of distribution and the vitality of buried weed-seeds.

READERS of NATURE who are interested in ancient herbals and old-time gardening and agriculture should see Catalogue No. 81 of *Messrs. Dulau and Co., Ltd.*, 34 Margaret Street, W.1, in which are to be found particulars of 1000 works dealing with these and other scientific subjects, many the property of the late Sir Frank Crisp. An unusual feature is a collection of volumes on sundials.

Our Astronomical Column.

BRIGHT METEORS.—A fine meteor was observed on February 17 at 8h. 52m. by Mr. F. Wilson, Totteridge, and Mr. S. B. Mattey, Plumstead. It was brighter than Jupiter, and moved very slowly from a radiant at 72°+43° near α Aurigæ. The approximate height of the object was 67 to 30 miles, path 53 miles, and velocity 10 miles per second. It passed from over south-west of Needham Market to Woodbridge.

Another very brilliant meteor was observed on February 27 at 8h. 58m. by Mrs. Wilson and Miss Cook, and also by Mr. S. B. Mattey at Plumstead. The radiant was at about 17°+8° near the horizon 9° north of west. The height of the object was 53 to 49 miles, path 95 miles, and velocity 12 miles per second. It passed from over Lydd, Kent, to about 50 miles east of Calais, France. Fireballs from Auriga and Pisces have been recorded in previous years at about the same dates as those of this year.

TOTAL LIGHT OF THE STARS.—The late Prof. Newcomb laid stress on the desirability of obtaining this observational constant, and several attempts have been made to do so. The latest is by Mr. P. J. Van Rhijn (Contributions from Mount Wilson Observatory, No. 173). This paper shows that there is illumination, which is probably due to (*a*) a faint extension of the zodiacal light, including the Gegenschein, and (*b*) faint auroræ. The amount of these was found by observing regions of the sky remote from the Galaxy and assuming that the starlight in these regions could be inferred from the observed number of stars of each order of magnitude. The amount of each of these is discussed, and it is concluded that the total amount of light received from all the stars in both hemispheres is equal to 1440 stars of magnitude 1·00, Harvard visual scale. The following are the values of extra-galactic sky brightness per square degree found by different observers, the unit being a star of magnitude 1·00:—Newcomb, 0·029; Burns, 0·050; Abbot, 0·075; Yntema, 0·140; and Van Rhijn, 0·130. The magnitude of the full moon is about −12; it is, therefore, about 140,000 times as bright as a star of magnitude 1·00, or a hundred times as bright as all the stars together.

STAR CLUSTERS.—*Scientia* for March contains the fourth of a series of papers on clusters by Dr. Harlow Shapley. Dr. Shapley quotes a remark that distance introduces simplification in our study of the clusters; it makes apparent magnitudes equivalent to absolute ones, since all the components are at practically the same distance from us. He then proceeds to consider the local cluster to which the sun belongs, which he regards as defined by Dr. Charlier's research on the distribution of the B stars in space. The conclusion was that they form a flattened cluster, with greatest diameter 4000 light-years. This is supposed to be merely one unit out of many that go to make up the galaxy. Its equatorial region is marked by a zone of bright stars, to which attention was directed by Sir J. Herschel and Dr. B. A. Gould. Its plane is inclined some 15° to the medial line of the galaxy. Dr. Charlier puts the centre of the local cluster in Carina, some 250 light-years from the sun; while Dr. Shapley makes the distance only 150 light-years.

Since from analogy the cluster is likely to be moving with respect to its neighbours, the two star-drifts would appertain respectively to cluster and non-cluster stars. It is left an open question to which category the sun belongs. Viewed telescopically from the Hercules cluster, the local cluster would seem to be mainly composed of B stars, with a smaller number of giant M ones. The sun would be of the twentieth magnitude, too faint for visual observation, though it might be photographed.

Meteorological Observations at Calcutta.[1]

THERE is a perpetual struggle between the advocates of continuity and of uniformity in such matters as meteorological observations. For a network of official stations under a central authority, the results of which have to be co-ordinated, uniformity is of very great importance. On the other hand, experiments with different methods are much less likely to be discouraged in an independent observatory, the work of which has a value of a totally different kind. In such a place continuity has a special significance, and it is refreshing to meet with a volume of data from a station that has been on the same site for fifty years, even though that site was criticised very soon after the beginning of the period.

The official observatory at Alipore is only two miles from St. Xavier's College, so that the latter is not required as a vital station for the Indian Meteorological Service, and the Jesuit Fathers, who have maintained their observatory for half a century, have received no special blame for departures from established practice, or any financial support. The Rev. E. Francotte, S.J., has been director for thirty-two years out of the fifty, and is responsible for the present volume of some 350 pages of very clear print with large figures not at all crowded. His full plan consists of four parts, of which the volume before us is the first. It contains for each day in the fifty years, 1868–1917, maximum, minimum, and mean shade temperature, with maximum solar radiation and minimum terrestrial radiation, barometric pressure, wind direction and velocity, relative humidity and rainfall; the monthly extremes in heavy type, with notes on absolute extremes where encountered. This is intended to show the mutual relations of climatic elements, and to further this object, in addition to the tables, some graphs are added. The original scheme was to publish at the end of forty-six years, and part of the volume is summarised for that period. The war, which held back publication, enabled four more years to be included in an appendix.

We have not space to consider in any detail the mass of data contained in the volume, but a few points of interest may be mentioned. In forty-six years the average number of days with at least 1 in. of rain was nineteen per annum. Daily falls of at least 10 in. occurred five times in the period, including one total fall of 14 in. The shade temperature reached 100° F. on 527 days in forty-eight years: 59 in March, 282 in April, 136 in May, 48 in June, and only 2 in July, both in 1897. Father Francotte examines some of the tables for periodicity, but is reserving a great deal more analysis for the second volume, the publication of which will be awaited with interest by those who have seen the first. W. W. B.

The Road to Industrial Peace.[2]

FROM time to time the Advisory Council of Science and Industry in the Australian Commonwealth issues bulletins dealing with various industrial problems, and the latest of its publications is entitled "Welfare Work," though it is wider in scope than the title is usually taken to imply. The preface tells us that the bulletin is prepared for the benefit of all who are seeking for some road to industrial peace and the establishment of more satisfactory and harmonious relations between capital and labour. It points out that these relations are far wider than questions of wages and hours of labour. A comprehensive industrial policy considers the responsibilities which fall on the shoulders of employers, the effect of industrial conditions on the employee, his well-being outside working hours, the distribution of the wealth produced, and the participation of the employees in the management and control of industrial operations. The bulletin sets out what has been done on these lines in Great Britain, the United States, and other countries, and in order to encourage its circulation it is issued at a very low price. It is to be hoped that it will receive the wide publicity it deserves, not only in Australia, but in this country as well. It is, in fact, of more direct interest to us than to its country of issue, in that all reference to welfare work in Australia is reserved for publication in a later bulletin.

The bulletin is admirably written, and affords a most valuable and impartial summary, especially of the large body of information which has been acquired during the war through the activity of the Health of Munition Workers Committee and other bodies. It describes the motives, scope, and administration of welfare work, and the social life, recreation, education, and housing of the workers. It discusses wage-payments, profit-sharing and co-partnership, provision for old age and sickness, and it goes somewhat fully into what is being more and more recognised as the most important factor of all in the attainment of industrial peace, viz. co-operation between employers and employed in control. The health and safety of the worker and the provision of a healthy industrial environment are debated at some length, whilst there is an excellent summary of problems of industrial fatigue in relation to hours of labour, overtime, and rest pauses. An extensive bibliography is included. H. M. V.

[1] "Meteorological Observations at St. Xavier's College, Calcutta. (With a Short, Cursory Discussion on the Same)." Part i., Forty-six Years, 1868–1913. With Appendix, 1914–17. By E. Francotte. Pp. xiv+350. (Calcutta: St. Xavier's College, 1918.) Price, unbound, Rs. 3 per copy.

[2] "Welfare Work." Bulletin No. 15 of the Advisory Council of Science and Industry. (Melbourne, 1919.) Pp. 110. Price 6d.

Wireless Telephony in Aeroplanes.

IN a paper read before the Wireless Section of the Institution of Electrical Engineers on February 18 Major C. E. Prince lifted the veil from the important results in wireless telephony from aeroplanes which were achieved in consequence of the stimulus of the necessities of war. Up to the summer of 1915, the author believes, wireless speech had not been received in an aeroplane, and, indeed, great were the difficulties that had to be surmounted before practical apparatus for working between ground and aeroplane or between aeroplane and aeroplane could be produced. In the earlier experiments, transmission from air to ground only was attempted by a small oscillation-valve set, but an aeroplane-carried receiving set, also of the oscillation-valve type, was successfully used in 1916. This, however, did not meet the immediate military requirements overseas, and attention was more particularly devoted to the urgent, but more difficult, problem of telephonic communication between machines in the air.

Major Prince gave a good idea of the difficulties encountered and the ingenuity with which he and his colleagues surmounted them. The crux of the problem is the method of controlling the radiation. Direct control was found to suffer from grave disadvantages. Placing a microphone in the grid circuit of the oscillation valve was tried with some success, but finally a method known as "choke" control, in which the modulation is applied to the anode circuit of a second or control valve, was employed. The grid of the control valve is acted on by the microphone transformer, the anode of which is in series with a one-to-one transformer, or choke coil, in the

anode circuit of the main valve. When variations take place in the control anode at speech frequency, very large surges are set up in that of the power valve, which may approximate to the original high-tension direct-current potential, and so sweep the output from nearly double its steady value to zero. The standard R.A.F. set is of the 20-watt size, with a high-tension supply of 600 volts direct current. A great advantage in the system for aeroplane work is that no critical adjustments are required. The arrangement of the apparatus is such that the set proper can be mounted in any convenient position, and only a very small control unit brought within reach of the user's hand. One switch makes or breaks the dynamo field, filament, and microphone circuits. A great deal of experiment was necessary before a suitable microphone was found, as it had to be almost insensible to sounds of "noise" intensity, but responsive to the powerful concentrated waves of a voice impinging upon it at a very short distance.

The receiving set depended upon high-frequency magnification, and was, in its first form, a three-valve arrangement. It consisted essentially of a detector valve with reaction and two note magnifications. The detector valve was not energised direct from the aerial, but through an aperiodic circuit, which was a circuit approximately syntonised by its self-capacity. The final adjustment for obtaining the best effect is made on a rheostat in the filament circuit carried on the "joystick" itself. These three-valve sets were employed to a considerable extent both before and after the armistice, but a five-valve receiver was developed later in which a choice was made of two high-frequency magnifications and two low, with a detector valve. This set was very much more sensitive than the three-valve arrangement, and enabled fixed aerials rigidly connected to the wings and fuselage to replace the trailing aerial, which latter was a great embarrassment in fighting. The normal safe range of the apparatus is about four miles from machine to machine, while the range to a ground station is from twenty to fifty miles or more. The author anticipates that in the future the wireless apparatus will be able to be plugged through on to the ordinary exchange lines, so that a man sitting in his office will be able to hold a conversation with a machine in the air.

Magnetic Storm of March 4-5.

THE Director of the Meteorological Office has been good enough to send us the subjoined communication from Dr. Chree concerning a magnetic storm which occurred on March 4 and 5. It may be mentioned that on these days the sky was mostly overcast in Scotland, though there was very fine weather in the South of England. We are informed that the only aurora observation reported so far was made at Aberdeen at 1h. 30m. on March 4, *i.e.* ten hours before the "sudden commencement" of the storm :—

"A considerable magnetic disturbance was recorded at Kew Observatory on the night of March 4-5.

"There was a well-marked S.C. (sudden commencement) at about 11h. 40m. on March 4. This was of an oscillatory character both in D (declination) and H (horizontal force). The first, smaller, movement was a fall in H and an easterly swing in D, the range of the oscillation being about 45γ in H and 7′ in D. H retained an enhanced value for four or five hours after the S.C., and no really large movements occurred until after 17h. on March 4. The most disturbed time was from 18h. on March 4 to 9h. on March 5. On the whole, H was falling from 17h. on March 4 until after 2h. on March 5, the maximum being recorded at about 16h. 20m. on March 4, the minimum at about 2h. 5m. on March 5, and the range being approximately 300γ. The H curve had become quiet before 10h. on March 5, but still showed a depression of about 75γ.

"The D trace was off the sheet, in the direction answering to easterly displacement, for fully twenty minutes between 22h. and 23h. on March 4; so the range recorded, 60′, may have been considerably exceeded. The maximum westerly displacement occurred at about 18h. 35m. on March 4.

"From 12½h. to 17½h. on March 4 the D trace was practically normal except that the declination was 1′ or 2′ more westerly than usual. Thus the disturbance was rather a conspicuous example of the lull that not infrequently intervenes between the S.C. and movements that would be recognised as constituting a magnetic storm."

University and Educational Intelligence.

CAMBRIDGE.—Mr. E. V. Appleton, of St. John's College, has been appointed an assistant demonstrator in experimental physics.

It is proposed to confer the honorary degree of D.Litt. on the Abbé Henri Breuil, professor of the Institute of Human Palæontology at Paris.

It is proposed to create a readership in the morphology of vertebrates and a lectureship in zoology in place of the present readership in zoology.

Besides additions and improvements to the chemical laboratory and the erection of the Molteno Institute for Parasitology, other building schemes are in view for engineering, physics, and also for the University library. The last proposal to meet the difficulty of finding room for books was to excavate a large underground chamber. The cost of this has been found to be prohibitive, and the Senate has recently discussed a revival of an old scheme to erect a new building akin to the Senate House and on the south side of Senate House Yard. If this scheme is adopted a public appeal will be made for subscriptions towards the erection of the building.

LEEDS.—Mr. W. E. H. Berwick has been appointed lecturer in mathematics in the University. Mr. Berwick was assistant lecturer in the University of Bristol for two years, and afterwards became lecturer in mathematics in University College, Bangor. For two years he was engaged on the technical staff of the Anti-Aircraft Experimental Section of the Munitions Inventions Department at Portsmouth, where he made important contributions to the experimental and computative theory of gunnery. He has published a long series of papers in the Proceedings of the London Mathematical Society and elsewhere.

OXFORD.—Prof. R. A. Sampson, Astronomer Royal for Scotland, has been appointed Halley lecturer for 1920.

THE governors and trustees of Tancred's studentships propose to elect a student in physic at Gonville and Caius College, Cambridge, at Whitsuntide. The annual value of the studentship is about 95*l*. Particulars are obtainable from Mr. E. T. Gurdon, 28 Lincoln's Inn Fields, W.C.2.

THE sixth annual report of the Carnegie United Kingdom Trust is an account of the work done by the Trust in 1919, and contains a statement of income and expenditure for the year. The committee had hoped that the coming of peace would have brought with it a great opportunity for institutions which

exist for philanthropic purposes. But the first year of peace has been a disappointment. Building operations, which form a very large part of the activities assisted by the Trust, are kept back because building is now so costly. The outstanding obligations already undertaken by the Trust are sufficient to absorb the greater part of the available income during the next five years. It is evident that further sums will be required to supplement grants already made for building libraries. The committee is, therefore, disinclined to consider new requests for grants in aid of library building. The committee considers that the assistance given to rural library schemes is among the most important and satisfactory of the Trust's activities. Under these schemes a box containing fifty books is sent to a small town or village and there used as a lending library until, the books having been read, it is time to exchange them for a fresh supply. Reports from those in charge of rural centres show that the scheme really provides a means for spreading education in thinly populated districts. The Carnegie Trust has made a grant towards the maintenance of the School of Librarianship recently established at University College, London. The highly trained students who pass through this school should do much to make our libraries more useful. The committee of the Carnegie Trust also reports on the part it has taken in physical welfare schemes and in the promotion of music.

AN appeal has just been issued by the University of London through its Military Education Committee inviting subscriptions to the war memorial which it is proposed to raise to the former officers and cadets of the University of London Officers Training Corps who have fallen in the war. The services rendered by the Officers Training Corps during the war are too little known or appreciated. When war broke out the cadets came forward practically as one man, and to their heroism and the unremitting labours (often in the teeth of great discouragement and difficulties) of their pre-war instructors we owe the fact that what might have proved a most dangerous gap in the supply of officers during the earlier part of the war was successfully bridged. The record of the University of London contingent appears to be second to none. The number of past and present officers and cadets who served in the war as officers is 4197, of whom we have to deplore the loss of no fewer than 657. The number of distinctions gained is 1650, including five V.C.'s (the only two surviving V.C.'s, Major Cloutman and Major White, both graduates of the University, are honorary secretaries of the appeal). In particular the gratitude of Londoners must go out to Major Sowrey, who brought down a Zeppelin in flames, and later a Gotha aeroplane. The scheme is to include a memorial in London, and, in addition, a permanent hall in connection with the new standing camp of the University of London O.T.C. at Great Kimble, near Princes Risborough, where special memorials to individuals may be put up, of which the first will commemorate Lt.-Col. Arthur Egerton, Coldstream Guards, the first adiutant of the contingent, whom all the original officers and cadets mourn as a personal friend. The appeal committee is a strong one, and includes many honoured names outside the University itself—in particular, those of Marshal Foch and of Field-Marshals Lord French and Sir Henry Wilson. It is to be hoped that every patriotic person who realises the part played by the British universities in the great national struggle and the importance of maintaining this splendid tradition will contribute generously towards the 30,000*l.* asked for. Contributions should be sent to the hon. treasurer at 46 Russell Square, London, W.C.1.

Societies and Academies.

LONDON.

Royal Society, February 26.—Sir J. J. Thomson, president, in the chair.—L. F. **Richardson**: Some measurements of atmospheric turbulence. The eddy-shearing stress on the ground is deduced from pilot-balloon observations. Values on land in any consistent dynamical units are found to range from 0·0007 to 0·007 times the value of m^2/ρ, where m is the mean momentum per volume up to a height of 2 km. and ρ is the density. Evidence is given to show that the eddy viscosity across the wind at Lindenberg increases with height, and, except near the ground, is much greater than the eddy viscosity along the wind. In parts iv. and v. the spreading of a lamina of smoke is considered. Osborne Reynolds's eddy stresses are studied. For one occasion an attempt was made to measure simultaneously all six components of stress by observing the motion of thistledown. The three direct stresses are easily measured. Not so the shearing stresses; however, one was found to be 2·4 times its probable error. The theory of the scattering of particles is summarised, and numerical values are derived from scattering. The "turbulivity" ξ is estimated from the rising cumuli in calm weather and found to be 10^8, applicable only in the sense of friction. Thus the whole range of ξ observed in the free atmosphere was from seven to a million, in contrast with 0·2 in perfectly still air. The eddy stresses observed have ranged in absolute value from 0·004 to 110 dynes cm^{-2}.—J. H. **Hyde**: The viscosities and compressibilities of liquids at high pressure. In the first place, experiments were made to determine the change in the value of the kinematical viscosity (η/ρ) of the various oils, and after this investigation was completed apparatus was designed for the determination of the change in density with pressure. The apparatus used for the determination of the kinematical viscosity consisted essentially of a system of two horizontal (the upper one of capillary dimensions) and two vertical tubes forming a closed circuit of liquor under pressure, the lower half of the circuit containing mercury and the upper half the liquid under test. One end of the tubular frame rests on a horizontal knife-edge, and the frame is supported in a horizontal position by a spiral spring. On the mercury being displaced by a given amount, flow will take place round the circuit owing to the difference of head, and it is evident that if the spring be so designed that its rate of extension is equal to the rate of change of head of the mercury, flow of the liquid under test will take place through the capillary tube under a constant pressure-difference and at a velocity which can be calculated from the rate of extension of the spring. In this way all the data required for the determination of the absolute kinematic viscosity of the fluid were determined. The determinations of the variation in density under pressure were made by measuring the decrease in volume of known quantity of the liquid enclosed in a steel cylinder sealed at one end and closed at the other by a long steel plunger. The cylinder and plunger were enclosed in a pressure vessel and the motion of the plunger for any particular pressure was measured. The density was calculated from the decrease in the volume thus measured. From the values of the density (ρ) and those of the kinematical viscosity (η/ρ) obtained for the oils, the values of the absolute viscosity (η) were calculated. The results show that the absolute viscosity of all the oils tested increases considerably with pressure.—A. **Russell**: The capacity coefficients of spherical conductors. It is proved that the capacity coefficient of a spherical

conductor equals its radius, together with the capacity of the condenser formed by the spherical surface on one side and the images in it of all external objects connected in parallel on the other. This theorem leads at once to relations between the capacity coefficients of a system of two spheres and the capacities of certain spherical condensers which lessens very appreciably the labour involved in computing the values of these coefficients which are required in practical work. The mutual coefficient also is given in terms of the capacity of a spherical condenser, and other relations between the various capacities used by engineers and physicists are proved. Finally, a method of finding the approximate value of the capacity between a sphere and distant large conductors is given.—C. **Cuthbertson** and Maude **Cuthbertson**: The refraction and dispersion of carbon dioxide, carbon monoxide, and methane. The refractivity of the above-named gases has been measured at eight points in the visible spectrum between λλ 6708–4800. The work was undertaken with the object of ascertaining the refractive power of the carbon atom, on the assumption of the validity of the additive law. By deducting the refractivity of the oxygen or hydrogen atoms from that of the carbon compound values are obtained from which the refractivity of carbon can be expressed in the form

$$\mu - 1 = \frac{C}{n_0^2 - n^2}.$$

For $1/\lambda = 0$ the expressions obtained are:

	From carbon dioxide	Carbon monoxide	Methane
$(\mu-1)_\infty$ carbon	$\frac{2\cdot7705}{16042} = 0\cdot000173$	$\frac{1\cdot988}{10213} = 0\cdot000195$	$\frac{1\cdot672}{10623} = 0\cdot000157$

There are thus wide differences, not only between the quotients, which give the refractivity, but also between the numerators, which should be proportional to the number of "dispersion electrons," and the denominators, which give the squares of the hypothetical free frequencies. The result affords a further proof that the "additive law" is untrustworthy except as a rough guide.—A. A. **Griffith**: The phenomena of rupture and flow in solids. Difficulties which had been experienced in predicting the fracture of machine parts under certain types of loading suggested the desirability of a fundamental inquiry into the mechanism of rupture. A theoretical criterion of the rupture of an elastic solid, based on the "theorem of minimum energy," is enunciated in the paper. This has been shown experimentally to be true in the case of a glass plate which contains a crack when unstrained. The calculation involves the surface tension of the material. In the experiments the maximum stress in the glass was estimated to be more than ten times the normal tenacity of the material. It is shown that this result is compatible with the general criterion of rupture unless the material is weakened by discontinuities of flaws the dimensions of which are at least of the order ten thousand times the molecular spacing. Evidence is adduced to show that the strength of other substances, including metals and liquids, is governed by similar considerations, and that an enormous increase in the tenacity of materials would be possible if the flaws could be eliminated. Experiments are described showing how the elimination may be performed in the case of glass and fused silica, it having been found possible to prepare samples of these materials with nearly fifty times their normal tenacity. The strong phase of these materials is, however, unstable, and changes spontaneously in a few hours to the normal modification. It is shown that many of the phenomena associated with the mechanical properties of materials, including those described in the present paper, are capable of explanation in general terms if it be supposed that intermolecular attraction is a function of the relative orientation of the attracting molecules. Some consequences of this theory are discussed in the paper. The paper concludes with a short discussion of the bearing of the work on engineering practice.

Geological Society, February 20.—Mr. G. W. Lamplugh, president, in the chair.—Annual general meeting.—G. W. **Lamplugh**: Presidential address: Some features of the Pleistocene glaciation of England. The address dealt principally with the changes brought about by the ice in the surface-features of our country. More than five thousand square miles of English land, or about one-tenth of the whole country, would vanish if the drifts were removed, as the "solid" rocks lie below sea-level in tracts of this extent. A further area of about ten thousand square miles is overspread by drift of sufficient thickness wholly to mask the "solid" land-forms, so that rather more than one-quarter of the country owes its present shape to Glacial and post-Glacial deposits. Another twenty thousand square miles was glaciated, and more or less modified, but without losing the dominating features of its rocky framework. The remainder of the country was affected only by the intensification of the atmospheric agencies, whereby its original features were accentuated. In a general sense, the hill-districts have not been greatly changed, but the lowlands have been in most parts completely altered. The source of the huge mass of material contained in certain of the lowland drift-sheets was considered, and the opinion was expressed that a large portion of this was an addition to the land, brought in by the ice from outside our present coast-line. Comment was made on the curious rarity of peat or other land-detritus in Boulder Clay known to have been derived entirely from the land, and this was thought to indicate that the conditions for a long period before the actual glaciation had been unfavourable for the growth of timber or peat-producing vegetation.

February 25.—Mr. R. D. Oldham, president, in the chair.—H. C. **Sargent**: The Lower Carboniferous chert-formations of Derbyshire. The chert-formations occurring in the Carboniferous Limestone and associated rocks of Derbyshire may be classified under two heads: (1) Those which owe their silica to gaseous or aqueous emanations from igneous rocks. (2) Those which derived their silica from the land by means of chemical denudation. The author considers that in both cases the silica was precipitated direct, and did not, to any considerable extent, pass through an intermediate stage of secretion by organisms with subsequent solution and redeposition. He adduces evidence to show that simultaneous deposition of silica and calcium carbonate often took place, and it is believed that, in such cases, segregation ensued, and sometimes resulted in the formation of nodules and lenticular masses of chert. It is suggested that the bedded cherts of terrestrial origin resulted from heavier precipitation of silica, comparatively free from calcium carbonate, and spread over the sea-floor by gentle currents. Metasomatic replacement of limestone and calcareous organisms by silica has taken place at their contact with the chert. Impurities in the silica have tended to limit such replacement. Organisms existing in the sea or on the sea-floor would be entangled in the precipitated silica, and their presence in the chert is thus explained. The blackness of some chert is shown to be due to the presence of carbonaceous matter. Ferrous iron may possibly have operated sometimes in the same way.

PARIS.

Academy of Sciences, February 16.—M. Henri Deslandres in the chair.—G. **Humbert**: The positive quadratic forms of Hermite in an imaginary quadratic body.—M. **Hadamard**: Certain solutions of a functional differential equation.—G. **Bigourdan**: Co-ordinates, instruments, and work of the Observatory of the Collège de France.—A. **Rateau**: The greatest range and maximum realisable velocities of aeroplanes.—M. Ciamician was elected a foreign associate in succession to the late Sir William Ramsay, and M. L. Bianchi a correspondant for the section of geometry in succession to M. Volterra, elected foreign associate.—G. **Cerf**: Remarks on a generalisation of Pfaff's problem.—B. **de Fontviolant**: Calculation of circular bridges.—D. **Pompeiu**: A condition equivalent to monogeneity and the demonstration of the fundamental theorem of Cauchy.—J. **Boccardi**: A diurnal variation of latitude.—A. **Guillet** and M. **Aubert**: An absolute bispherical electrometer. The numerical calculation of its characteristics.—S. **Procopiu**: Diffraction grating spectra in the case where the incident light is oblique with respect to the principal plane of the lines.—A. **Pérard**: A method for the comparison and measurement in absolute value of standards with plane ends by an interference method.—Ch. **Boulin** and L. J. **Simon**: The action of water on dimethylsulphate.—F. **Canac**: The determination of the parameters of a crystal by the X-rays.—M. **Zeil**: The ascending movements of the earth's crust and the evolution of fossil remains.—G. **Denizot**: The existence of two peneplains in the Paris basin.—P. **Guerin** and Ch. **Lormand**: The action of chlorine and various vapours upon plants. After one or two hours' exposure to an atmosphere containing 1/2000 of chlorine, bromoacetone, and other poison gases, most plants resist; they lose their leaves, but new ones appear, and the plants finish their normal growth.—H. **Coupin**: The production of chlorophyll by plants exposed to a discontinuous light.—J. **Amar**: The index of respiratory endurance. This is defined as the ratio of the volume of air entering the lungs at each inspiration to the body-weight.—H. V. **Vallois**: Evolution of the muscle system of the episome in vertebrates.—L. **Mercier**: Variation of *Corophium volutator* according to its place of origin.—E. **Chatton**: The existence in Radiolaria of parasitic Periclinians considered as forms of reproduction of their hosts.

Books Received.

The Story of Milk. By J. D. Frederiksen. Pp. xx+188. (New York: The Macmillan Co.; London: Macmillan and Co., Ltd.) 9*s*. net.

The Handbook of Cyprus. Eighth issue. Edited by H. C. Luke and D. J. Jardine. Pp. xii+300. (London: Macmillan and Co., Ltd.) 12*s*. net.

A First-Year Physics for Junior Technical Schools. By G. W. Farmer. Pp. x+183. (London: Longmans and Co.) 4*s*. 6*d*.

Practical Hardy Fruit Culture. By R. Staward. Pp. 216. (London: The Swarthmore Press, Ltd.) 6*s*. net.

A First Book of School Celebrations. By Dr. F. H. Haywood. Pp. 167. (London: P. S. King and Son, Ltd.) 5*s*.

The Chemical Age. June–December, 1919. Pp. xi+750. (London: Benn Bros., Ltd.) 15*s*.

Mauka Polska Jej Pstrzeby, Organizaeja i Rozwój. Tom i. Pp. xvi+558. (Warszawa.) Cena M.P. 15.

The Elementary Differential Geometry of Plane Curves. By R. H. Fowler. Pp. vii+105. (Cambridge: At the University Press.) 6*s*. net.

The Foundations of Einstein's Theory of Gravitation. By E. Freundlich. Authorised English translation by H. L. Brose. Preface by A. Einstein. Introduction by Prof. H. H. Turner. Pp. xvi+61. (Cambridge: At the University Press.) 5*s*. net.

Through Deserts and Oases of Central Asia. By Miss Ella Sykes and Brig.-Gen. Sir Percy Sykes. Pp. xii+340. (London: Macmillan and Co., Ltd.) 21*s*. net.

The Origin and Development of the Compositæ. By Dr. J. Small. Pp. xi+334+6 plates. (London: W. Wesley and Son.) 15*s*. net.

A Text-book on Machine Drawing for Electrical Engineers. By E. Blythe. Pp. vii+81. (Cambridge: At the University Press.) 20*s*. net.

La Molécule Chimique. By Prof. R. Lespieau. Pp. iii+286. (Paris: F. Alcan.) 3.50 francs.

L'Unité de la Science. By Prof. M. L. du Sablon. Pp. iii+284. (Paris: F. Alcan.) 3.50 francs.

The Examination of Materials by X-rays. Pp. ii+64. (London: Faraday Society.) 13*s*. 6*d*.

The Physiology of Vision: With Special Reference to Colour Blindness. By Dr. F. W. Edridge-Green. Pp. xii+280. (London: G. Bell and Sons, Ltd.) 12*s*. net.

Diary of Societies.

THURSDAY, MARCH 11.

ROYAL INSTITUTION OF GREAT BRITAIN, at 3.—Lt.-Col. E. Gold: The Upper Air: (ii) Results and their Interpretation.

INSTITUTE OF METALS (at Institution of Mechanical Engineers) (Annual General Meeting), at 4.—Eng. Vice-Admiral Sir George Goodwin: Inaugural Address.

ROYAL SOCIETY, at 4.30.—W. G. Duffield, T. H. Burnham, and A. A. Davis: The Pressure upon the Poles of Metallic Arcs, including Alloys and Composite Arcs.—J. H. Vincent: Further Experiments on the Variation of Wave-length of the Oscillations Generated by an Ionic Valve Due to Changes in Filament Current.—H. A. Daynes: (1) The Theory of the Katharometer; (2) The Process of Diffusion through a Rubber Membrane.

LONDON MATHEMATICAL SOCIETY, at 5.—G. S. Le Beau: A Property of Polynomials whose Roots are Real.—B. M. Sen: Double Surfaces.

ROYAL COLLEGE OF PHYSICIANS, at 5.—Dr. J. L. Birley: The Principles of Medical Science as applied to Military Aviation (Goulstonian Lecture).

ROYAL INSTITUTE OF PUBLIC HEALTH, at 5.—Dr. H. M. Berry: X-rays in the Diagnosis of Tuberculosis.

ROYAL SOCIETY OF MEDICINE (Occasional Lecture), at 5.—Sir Jagadis Bose: Plant and Animal Response (with Demonstrations of Growth by the Magnetic Crescograph).

CHILD-STUDY SOCIETY (at Royal Sanitary Institute), at 6.—Dr. M. Jane Reaney: The Educational Needs of Adolescence.

INSTITUTION OF ELECTRICAL ENGINEERS (at Institution of Civil Engineers), at 6.—W. H. Patchell: Operating a By-product Producer-gas Plant for Power and Heating.—S. H. Fowles: Production of Power from Blast-furnace Gas.

OIL AND COLOUR CHEMISTS' ASSOCIATION (at 2 Furnival Street), at 7.—J. B. Shaw: Various Points in the Manufacture of Lake and Pigment Colours.

OPTICAL SOCIETY, at 7.30.—A. C. W. Aldis: Portable Electric Signalling Lamps.

INSTITUTION OF AUTOMOBILE ENGINEERS (Graduate Section), at 8.—C. A. Chappell: Magnetos.

INSTITUTE OF METALS (at Institution of Mechanical Engineers) (Annual General Meeting), at 8.—Dr. G. D. Bengough, R. M. Jones, and Ruth Pirret: Fifth Report to the Corrosion Research Committee.—R. Seligman and P. Williams: The Action on Aluminium of Hard Industrial Waters.

ROYAL SOCIETY OF MEDICINE (Neurology Section), at 8.30.—Prof. J. S. B. Stopford: Results of End-to-end Suture of Peripheral Nerves.

SOCIETY OF ANTIQUARIES, at 8.30.

FRIDAY, MARCH 12.

INSTITUTE OF METALS (at Institution of Mechanical Engineers) (Annual General Meeting), at 10.30.—J. Neil MacLean: The Art of Casting in High Tensil: Brass.—H. Moore and S. Beckinsale: The Removal of Internal Stress in 70: 30 Brass by Low-temperature Annealing.—Dr. W. Rosenhain, J. L. Haughton, and Kathleen Bingham: Zinc Alloys with Aluminium and Copper.—Dr. W. Rosenhain: A Model for Representing the Constitution of Ternary Alloys.—A. C. Vivian: Tin-Phosphorus Alloys.—W. C. Hothersall and E. L. Rhead: Some Notes on the Effect of Hydrogen on Copper.

INSTITUTE OF METALS (at Institution of Mechanical Engineers) (Annual General Meeting), at 2.30.—W. E. Alkins: The Effect of Progressive Drawing upon some Physical Properties of Commercially Pure Copper.—F. Johnson: The Influence of Cold Rolling on the Physical Properties of Copper.—J. L. Haughton: The Study of Thermal Electro-motive Force as an Aid to the Investigation of the Constitution of Alloy Systems.—H. H. Hayes: The Polishing and Etching of Zinc for Micro-examination.—W. E. Hughes: Idiomorphic Crystals of Electro-deposited Copper.

ROYAL ASTRONOMICAL SOCIETY, at 5.—N. Liapin: Some Remarkable Properties of Diurnal Motion.—H. C. Plummer: The Nature of Short-period Variables.—L. Becker: (1) Capture Orbits; (2) The Capture Hypo-

thesis of Binary Stars.—T. C. Hudson: A Vectorial Theorem—R. A. Sampson: Theory of the Four Great Satellites of Jupiter.—J. Jackson: The Orbits of 20 Double Stars.—H. W. Newton: Note on the Sun-spot and Faculæ Disturbance in the Region of the Eclipse Prominence of 1919.—A. S. Williams: The Observed Changes in the Colour of Jupiter's Equatorial Zone.—A. R. Hinks: A Preliminary Account of the Geography of the 1922 September 20 Eclipse Track.

PHYSICAL SOCIETY OF LONDON, at 5.—F. W. Newman: Absorption of Gases in a Discharge Tube.—F. S. G Thomas: A New Directional Hot-wire Anemometer of High Sensitivity, especially applicable to the Investigation of Slow Rates of Flow of Gases.—Dr. Hans Pettersen: Exhibit of a New Micro-balance.

UNIVERSITY COLLEGE ENGINEERING SOCIETY (Annual Public Meeting), at 5.30.—Sir Dugald Clerk: Coal Conservation.

MALACOLOGICAL SOCIETY OF LONDON (at Linnean Society), at 6.

INSTITUTION OF MECHANICAL ENGINEERS (Informal Meeting), at 7.—A. J. H. Fitt and Others: Costing.

JUNIOR INSTITUTION OF ENGINEERS, at 7.30.—F. A. Simpson: Chain Helice Pumps.

HARVEIAN SOCIETY (at the Medical Society of London), at 8.30.—Sir Thomas Horder: The Diagnostic Significance of Nerve Symptoms in Acute Infections (Harveian Oration).

ROYAL INSTITUTION OF GREAT BRITAIN, at 9.—W. W. Rouse Ball: String Figures.

SATURDAY, MARCH 13.

ROYAL INSTITUTION OF GREAT BRITAIN, at 3.—Sir J. J. Thomson: Positive Rays.

MONDAY, MARCH 15.

VICTORIA INSTITUTE (at Central Hall, Westminster), at 4.30.—E. W. G. Masterman: The Walls of Jerusalem at Various Periods.

ROYAL SOCIETY OF MEDICINE (Occasional Lecture), at 5.—Dr. J. Freeman: Toxic Idiopathies: The Relationship between Hay and other Pollen Fevers, Animal Asthmas, Food Idiosyncrasies, Bronchial and Spasmodic Asthmas, etc.

INSTITUTION OF ELECTRICAL ENGINEERS (Informal Meeting) (at Chartered Institute of Patent Agents), at 7.—J. W. Beauchamp and S. M. Hills: Industrial Electric Heating.

ROYAL INSTITUTE OF BRITISH ARCHITECTS, at 8.—H. Austen Hall: The Planning of American Departmental Stores.

SURVEYORS' INSTITUTION, at 8.

ROYAL GEOGRAPHICAL SOCIETY (at Æolian Hall), at 8.30.—Prof. J. L. Myres: The Dodekanese.

TUESDAY, MARCH 16.

ROYAL INSTITUTION OF GREAT BRITAIN, at 3.—Prof. A. Keith: British Ethnology—The Invaders of England.

ROYAL COLLEGE OF PHYSICIANS, at 5.—Dr. J. L. Birtley: The Principles of Medical Science as applied to Military Aviation (Goulstonian Lecture).

ROYAL SOCIETY OF MEDICINE, at 5.—(Special General Meeting of Fellows.)

ROYAL STATISTICAL SOCIETY, at 5.15.—M. S. Birkett: The Iron and Steel Trades during the War.

INSTITUTION OF CIVIL ENGINEERS, at 5.30.—Sir Alexander B. W. Kennedy; Lantern Exhibition of Views taken throughout the War Areas in France and Flanders.

INSTITUTION OF PETROLEUM TECHNOLOGISTS (at Royal Society of Arts), at 5.30.—M. A. Ockenden and A. Carter: Plant used in the Rotary System of Drilling Oil Wells.

MINERALOGICAL SOCIETY (at Geological Society), at 5.30.—A. Russell: The Occurrence of Cotunnite, Anglesite, Leadhillite, and Galena on Fused Lead from the Wreck of the Fireship *Fire randa*, Falmouth Harbour, Cornwall.—W. Campbell Smith: Riebeckite-rhyolite from Northern Kordofan.—Dr. G. T. Prior: The Meteoric Iron of Mount Ayliff, Griqualand East, South Africa.

ZOOLOGICAL SOCIETY OF LONDON, at 5.30.—R. I. Pocock: The External Characters of South American Monkeys.—Dr. C. F. Sonntag: The Comparative Anatomy of the Tongues of the Mammalia: I. General Description of the Tongue.

ROYAL PHOTOGRAPHIC SOCIETY OF GREAT BRITAIN (Lantern Meeting), at 7.—Maj.-Gen. W. S. Brancker: Bird's-Eye Views of London and other Districts in England from Aeroplane Photographs.

ROYAL ANTHROPOLOGICAL INSTITUTE, at 8.15.—N. W. Thomas: The Ovia Secret Society (Illustrated by Lantern Slides and Phonograph Records).—Surg.-Lt. R. Buddle: Exhibition of Flint Implements from Russia.

WEDNESDAY, MARCH 17.

ROYAL UNITED SERVICE INSTITUTION, at 3.—Major H. F. S. Huntington The Physical and Ethical Value of Boxing.

ROYAL SOCIETY OF ARTS, at 4.30.—W. W. Beaumont: Street Passenger Transport of London.

ROYAL METEOROLOGICAL SOCIETY (at Royal Astronomical Society), at 5.—Capt. C. K. M. Douglas: Clouds as seen from an Aeroplane.

INSTITUTION OF ELECTRICAL ENGINEERS (Wireless Section) (at Institution of Civil Engineers), at 6.—Capt. P. P. Eckersley: Duplex Wireless Telephony: Some Experiments on its Application to Aircraft.

ROYAL AERONAUTICAL SOCIETY (at Royal Society of Arts), at 8.—Major C. F. Abell: Airship Machinery.

ROYAL MICROSCOPICAL SOCIETY, at 8.

THURSDAY, MARCH 18.

ROYAL INSTITUTION OF GREAT BRITAIN, at 3.—Stephen Graham: The Spirit of America after the War.

ROYAL SOCIETY, at 4.30.—*Probable Papers*.—W. B. Brierley: A Form of *Botrytis cinerea* with Colourless Sclerotia.—R. R. Gates: A Preliminary Account of the Meiotic Phenomena in the Pollen Mother Cells and Tapetum of Lettuce (*Lactuca sativa*).

LINNEAN SOCIETY, at 5.

ROYAL COLLEGE OF PHYSICIANS, at 5.—Sir John R. Bradford: The Clinical Experiences of a Physician during the Campaign in France and Flanders, 1914-1919 (Lumleian Lecture).

INSTITUTION OF MINING AND METALLURGY (at Geological Society), at 5.30. W. R. Jones: Tin and Tungsten Deposits: The Economic Significance of their Relative Temperatures of Formation.

INSTITUTION OF ELECTRICAL ENGINEERS (at Institution of Civil Engineers), at 6.—Adjourned Discussion on the Papers of W. H. Patchell and S. H. Fowles read at the Meeting on March 11.

CHEMICAL SOCIETY, at 8.—I. Masson and R. McCall: The Viscosity of Nitrocellulose in Mixtures of Acetone and Water.—H. Stephen, W. F. Short and G. Gladding: The Introduction of the Chloromethyl Group into the Aromatic Nucleus.—H. E. Cox: The Influence of the Solvent on the Velocity of Reaction between certain Alkyl Iodides and Sodium β-Naphthoxide.—H. Crompton and P. L. Vanderstichele: The Use of 1:2-Dichlorovinylethyl Ether for the Production of Chloroacetates and Acid Chlorides.

FRIDAY, MARCH 19.

ROYAL SOCIETY OF ARTS (Indian Section), at 4.30.—Sir William S. Meyer: The Indian Currency System and its Developments.

CONCRETE INSTITUTE, at 6.—Dr. O. Faber: The Practical Application of Reinforced Concrete.

INSTITUTION OF MECHANICAL ENGINEERS, at 6.—D. Brownlie: Exact Data on the Performance of Mechanical Stokers, as applied to "Lancashire" and other Narrow-flued Boilers.

ROYAL INSTITUTION OF GREAT BRITAIN, at 9.—E. McCurdy: Leonardo da Vinci.

SATURDAY, MARCH 20.

ROYAL INSTITUTION OF GREAT BRITAIN, at 3.—Sir J. J. Thomson: Positive Rays.

PHYSIOLOGICAL SOCIETY (at University College), at 4.—J. F. Donegan and Others: Innervation of Veins.

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